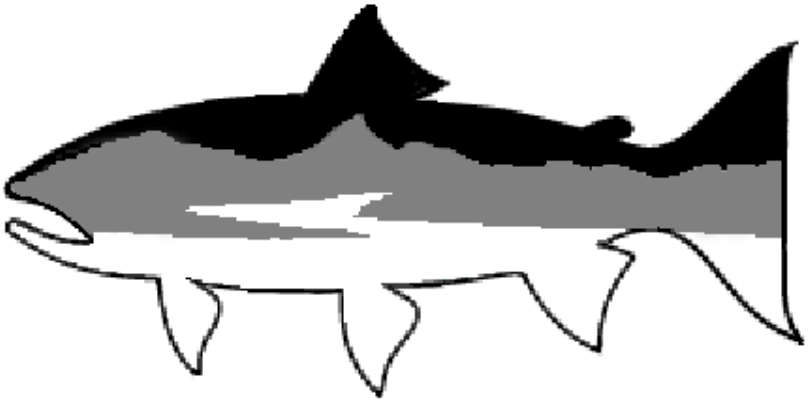
Field Protocol Manual

Aquatic and Riparian Effectiveness Monitoring Program

Regional Interagency Monitoring

for

The Northwest Forest Plan



2017 Field Season

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Introduction

The Northwest Forest Plan, hereafter referred to as “the Plan”, was approved in 1994. The Plan includes an Aquatic Conservation Strategy that requires the protection, rehabilitation, and monitoring of aquatic ecosystems under the Plan’s jurisdiction (USDA-USDI 1994). The Aquatic and Riparian Effectiveness Monitoring Program (AREMP or the monitoring plan) was developed to fulfill these monitoring requirements. The primary purpose of AREMP is to determine the current condition of 6th-field watersheds and track changes in watershed condition over time. A total of 250 watersheds will be monitored under AREMP. One of the most important aspects of the program is the collection of consistent data throughout the Northwest Forest Plan area to provide comparative data used to assess watershed condition.

As natural variance both within and between the watersheds is quite high, it is imperative that errors due to sampling and observer bias are minimized. The data collected will be used as the basis for management decisions throughout the Pacific Northwest. These data comprise one of the largest data sets that exist in the Pacific Northwest, both spatially and temporally. Therefore, it is of the utmost importance to make the effort to produce the highest quality data possible.

The goal is to efficiently and safely collect the best data possible within a watershed.

Order of Events for Sampling

1. Navigate to the site using all information including recon packet (maps, driving directions, hiking directions, UTMs, etc.)
2. Find the exact location of Transect A at the site using GPS and photos of Transect A on the Tablet.
3. At Transect A
    a. 1st and 2nd collects and records:
        i. Macroinvertebrates
        ii. GPS
        iii. Monument
        iv. Photos
4. Transect A to K
    a. 3rd and 4th surveyors layout the reach from A-K, including transects, pools and side channels
        i. Measure water quality (YSI and grab sample)
    b. 1st and 2nd surveyors measures the first trial of gradient.
5. At Transect K
    a. 3rd surveyor collects eDNA above Transect K
    b. 1st and 2nd surveyor collects and records:
        i. GPS
        ii. Monument
        iii. Photos
6. Transect K to A
    a. 4th surveyor records substrate measurements from Transects K-A2.
    b. 1st and 2nd surveyors measure the second trial of gradient.
7. Transect A to K
    a. 3rd and 4th surveyors estimates and measures large wood.
    b. 1st and 2nd surveyors measure cross sections at major transects and pool attributes including pool tail fines
    c. First team to finish wood or transects/pools conducts invasive species searches at AB, FG and JK while the last team pulls flags.
8. Check for entrenchment
9. Before leaving the reach, be sure to:
    a. Collect all transect (except Tran A), pool and side channel flags
    b. Pack up macroinvertebrate sample and water samples
    c. Review the check completion reports in the workbooks to ensure all data forms and fields have been filled out.

Surveying Basics

Thalweg
• The line connecting the deepest part of the channel
• It almost always the fastest flow in any river
• The thalweg moves back and forth across a channel

River right (RR) and river left (RL) – are always relative to the observer looking down stream
River right (RR) is to the right of an observer looking downstream.
River left (RL) is to the left of the observer looking downstream.

Locating and Establishing the Start of the Survey

A topographic map of each watershed will be supplied, marked with potential sample sites. The goal is to sample all sites that had been previously surveyed. Contact the field coordinators if extra personnel is going to be needed to finish a watershed.

Navigating with the Garmin Colorado 400t

1. To access the "Where To?" Menu:
    a. Select Shortcuts > Where To?
    b. Select the preferred search category (usually Waypoints or POI).
    c. Select a point. A green circle containing the word "GO" appears at the bottom of the page.
    d. Press Enter.
2. To navigate to a point on the map:
    a. On the Map page, use the Rock 'n Roller to move the pointer to a location and press ENTER, a green circle containing the word "GO" appears at the bottom of the page.
    b. Press ENTER.
3. During navigation, select Shortcuts > Compass and follow the red arrow.

Navigating with the Garmin Oregon 400t

1. From Main Menu: tap "Where To?"
    a. Select the preferred search category (usually Waypoints or POI).
    b. Select a point. A green circle containing the word "GO" appears at the bottom of the page.
    c. Tap the green circle.
2. To navigate to a point on the map:
    a. On the Map page, tap a location, an info box will appear at the top of the screen. Tap the box, a green circle containing the word "Go" appears at the bottom of the page.
    b. Tap the circle.
3. During navigation, from the Main Menu select Compass and follow the red arrow.

Selection Criteria

Note: A crew leader has the authority at any time to exclude a site if he/she feels it is unsafe for a crew to sample.

Exclude a watershed if:

1. It is deemed dangerous for a survey crew to be working in the area (i.e., law enforcement personnel identify a watershed as having prevalent drug growing operations). *Safety.*
2. Fire activity blocks or limits road/trail access to the watershed or has potential to spread, endangering the crew while working in the stream. *Safety.*
3. Less than 25% of the total stream length is located on federal land (done in office). *Ownership.*
4. A minimum of sampling four sites cannot be completed within six days (the length of time available each sampling trip) due to time constraints, accessibility issues, or site constraints (see below). *Accessibility.*

Exclude a site if:

1. The site is not safely accessible; i.e., it cannot be reached without putting the crew in danger. (A long hike into a steep canyon does not automatically qualify as a dangerous situation for the crew.)
2. The site is not wadeable because of depth or current.
3. Travel time (round trip) from road camp or wilderness camp is over four hours to get to and from the site. The crew should never be in the position of hiking back to camp or their truck in the dark. If the watershed is large and sites are spread out, a crew will relocate camp to be closer to outlying sites to reduce daily travel time.
4. The GPS point (used to identify the beginning of a site) is located on private land.
5. The GPS point for a site is located in a lake, wetland or marsh, or on a dam or glacier.
6. The site is an artificial stream or irrigation canal.

Include a site if:

1. All stream channels will be considered, regardless of the presence or absence of flowing water. Use the following criteria to determine whether the site should be sampled;
    a. Active scour must be present in the channel, i.e., fine particles have been removed or pushed to the side and larger substrate is visible. Ephemeral streams that flow over vegetation are not sampled.
    b. There must be well-defined bankfull indicators present to sufficiently establish survey transects throughout the length of the site, signifying that it is an active channel. An active channel will have some combination of the following bankfull indicators:
        i. Examine stream banks for an active floodplain. This is a relatively flat, depositional area that is commonly vegetated and above the bankfull elevation.

ii. Examine depositional features such as point bars. The highest elevation of a point bar usually indicates the lowest possible elevation for bankfull stage. However, depositional features can form both above and below the bankfull elevation when unusual flows occur during years preceding the survey. Large floods can form bars that extend above bankfull whereas several years of low flows can result in bars forming below bankfull elevation.

iii. A break in slope of the banks and/or change in the particle size distribution from coarser bed load particles to finer particles deposited during bank overflow conditions.

iv. Locate the elevation where mature key riparian woody vegetation exists. The lowest elevation of birch, alder, and dogwood can be useful, whereas willows are often found below the bankfull elevation.

v. Examine the ceiling of undercut banks. This elevation is usually slightly below the bankfull elevation.

vi. Stream channels actively reform bankfull features such as floodplains after shifts or down cutting in the channel. Be careful not to confuse old floodplains and terraces with the present indicators.

c. The survey crew must be able to physically work and collect a full set of data within the stream channel. Avoid sites choked with willows (or similar dense vegetation) that excessively hinder the crew's productivity or restrict mobility while working in the channel.

Note: Do not, under any circumstances, walk on private land to access sites. Your presence on private land is considered trespassing, regardless of what you are doing.

Record the site UTM coordinates

The EOS Arrow 100 is a high accuracy (sub-meter) GNSS (Global Navigation Satellite System) that utilizes SBAS (Satellite Based Augmentation Systems) to obtain real-time GPS corrections which when used properly can provide accurate spatial locations even in densely forested areas. The Arrow 100 will be used to collect a point at Transect A and Transect K. The Garmin units will only be used as a backup to collect these points.

To configure the Arrow with an Android device via Bluetooth, go to the Android "Settings" and select the Bluetooth icon. Turn ON the Bluetooth radio button and tap "SCAN" in the Settings menu located next to the search icon. The Arrow will be discovered and listed. Make sure the Arrow device number matches the number located on the bottom of the Arrow 100.

Tap on the Arrow under the "Available devices" and allow a few seconds to pair.

From the EOS Tools Pro App, in the "Settings" drop-down, choose "Select GPS Device" and choose the Arrow from the list. Go back to the setting menu and tap on "Start GPS". Next, in the settings menu check the "Enable Mock Location" feature to allow the Android Location Service to be populated with the Arrow's position coordinates.

When collecting a point hold/mount the antenna preferably above your head and without obstruction by your body. The antenna must have an unobstructed, clear view of the sky, for optimal performance (won't always be possible in forested streams). Do not lay the antenna directly on the ground to collect a point.

On first power up, allow the Arrow to track satellites in DGNSS for at least 10 minutes, prior to hiking towards the stream. Start the receiver at the truck before hiking into forest where the clearest view of the sky is so the SBAS satellites download a "fresh" almanac which increases the tracking performance under tougher environments (forested areas).

EOS Arrow 100

1. Select S1 Mobile App > Select a basemap from list icon.
2. Select the settings icon > Connect to Bluetooth GPS > Select the Arrow.
3. Select the plus icon > S1Waypoints > Select the Bullseye.
4. Select the Averaging icon (right of Bullseye) > Select the Attribute icon at the top of the screen.
5. When the attribute screen comes up enter in the name field the following naming convention {creek_code}{site_no}{reach location}. e.g. ORABC####k. Then hit the check mark at the top of the screen.

Garmin Colorado 400t

1. Select Shortcuts > Waypoint Averaging > Options > Create Waypoint.
2. When the Sample Confidence reaches 100%, select Save.

3. Edit waypoint name (Shortcuts > Waypoint Manager>select correct waypoint>Change Name) following the naming convention {creek_code}{site_no}{reach location}. e.g. ORABC####k.

   Note: Make sure to use the letter “O” and the number “0” in the appropriate locations when naming a site (i.e., ORABC1007)

Garmin Oregon 400t

1. Select Waypoint Averaging > Options > Create Waypoint.
2. When the Sample Confidence reaches 100%, select Save.
3. Edit waypoint name (Waypoint Manager>select correct waypoint>Change Name) following the naming convention {creek_code}{site_no}{reach location}. e.g. ORABC####k.

Monument the Site

Site markers are used to monument the site location. The markers will assist others in finding the start of the original site. ***Site markers will not be placed in wilderness areas and National Parks.***

1. Locate a distinct feature near the bottom of the site for Tran A and near the top of the site at Tran K that will be easily identified by the next survey crew.
    a. Something relatively permanent such as a piece of large wood near the stream (e.g. a large spanner log or tree).
    b. Sometimes riparian zones within the sites are characterized by a continuous patch of vegetation; try to pick something that stands out such as a large cottonwood tree or one conifer near the start of the site.
2. Use an aluminum nail to attach the monument. Leave 3-4 inches of space between the nail head and tree so the tree has room to grow and won't pop out the monument over time. Make sure the marker is clearly visible and facing the stream.
3. Next, standing at the marker location, take a manual compass bearing from the marker to Transect A/K Left Bank. Record this bearing in the tablet.

Photo Documentation

Information about each site will be documented in photographs and in the field data recorders. Ask all other crew members to stay out of the photos. Gear in the photos is OK as long as it does not move between pictures. Keep gear bundled up to avoid the "yard sale" look. Nine photos will be taken at Transect A and five at Transect K. In addition, photographs should be taken of rare or unique features in the site including culverts, log jams, landslides, beaver dams, or vertebrates that are difficult to identify.

Note: In wilderness areas/National Parks no monument is placed for photos instead choose a distinctive feature to use as the marker and take a photo of it with someone either pointing at it or temporarily hang a piece of flagging on the feature.

1. Turn on your camera and do the following:
    a. Ensure the image quality is set to three stars by pushing the "MENU" button and scrolling down to Quality Level.
    b. Use the "MACRO" feature for up close shots including the GPS and whiteboard.
    c. Select the "MACRO" button again to scroll to AF mode or Standard focus mode for all other shots.
    d. At the beginning of each day, open the screen on the GPS unit that displays the time and take a photo of it with the digital camera. This photo serves as a backup in case the digital camera clock varies.
    e. Take a picture of this screen, attempting to minimize glare. Look at the picture on the viewfinder to ensure that the numbers on the GPS unit can be read.

2. Hold the camera as still as possible while taking the photos. Remember that these photos will be used to repeat sites and look at changes to the stream channel so picture quality is very important.

Order of Events for Photographs at Tran A

1. GPS screen showing date and time
2. Close-up of white board with site information
    a. Location (i.e., watershed code name and site number): For Site 3 on Wadeable Creek in Oregon, you would put "ORWAD1003" or ORWAD9003 for QAQC.
    b. Date (Day Month Year): "3 July 2003"
    c. "Transect A LB."
3. Transect A left bank with whiteboard
4. Downstream from Transect A
5. Transect A right bank
6. Upstream from Transect A
7. Transect A left bank to Monument
8. Monument to Transect A left bank.
9. Approach to monument
10. Any other additional photos needed to capture distinctive features

Order of Events for Photographs at Tran K

1. Transect K left bank
2. Downstream from Transect K
3. Transect K right bank
4. Upstream from Transect K
5. Transect K left bank to Monument

Additional Photos to Take

Take photos that will help give people who may never visit the area an idea of what it looks like. These photos should help show the condition of the areas sampled, species captured at each site, land disturbances, etc. Take pictures of the following:

- Features such as logjams, road crossings, waterfalls, deep pools, and beaver dams.
- Land disturbances such as fires, landslides, extensive blow downs, etc.
- Unusual species and species that are difficult to identify; this info should also be entered into the photo log and incidentals form along with the photo number (see the photographs of biota).
- If possible, take a picture of the overall watershed (from a road/clearing).
- Scenic shots and photos of **SMILING** ☺ people working.

Site Layout

The majority of sites visited will have been previously surveyed (if not see Appendix A) and the reach length for the site will be in tablet. The site lengths are found in Table 1. In all sites, 11 transects will be laid out and labeled A-K with orange flagging. In addition to the 11 major transects, 10 intermediate transects will be flagged with orange flagging. Side channels and pools will also be identified and marked with pink and blue flagging respectively. Transect A will be marked with biodegradable orange flagging.

Following the thalweg, measure the distance between transects using a meter tape. The meter tape should be laid on the surface of the water at the thalweg. Flags will be labeled beforehand but make sure the correct flag is placed at the appropriate transect. Place an orange flag in an obvious area near eye level at each transect location.

***If a sharp bend in the channel is encountered while measuring between transects, split the measurement at the apex of the bend in order to accurately capture the channel length.*

***Remove all flagging from the site (except for the Transect A flag) after the survey is completed. Keep the flagging to reuse for future surveys.**

Table 1— Average bankfull width categories with corresponding site length.

Average Bankfull Width in meters	Width Category	Site Length in meters
1 to 8	8	160
8.1 to 10	10	200
10.1 to 12	12	240
12.1 to 14	14	280
14.1 to 16	16	320
16.1 to 18	18	360
18.1 to 20	20	400
20.1 to 22	22	440
≥22.1	24	480

Unusual Situations

Since stream channels come in a variety of sizes and shapes, situations will frequently arise that are not addressed in this protocol. In this case, the crew leader should make the best logical decision and document the situation in their crew leader notebook and transcribe it to the post-stint data form for that site. Unusual situations include the following; details are presented in Table 2.

Intermittent/Partial Flow

Not all streams will have water flowing throughout the entire reach; there may be sections that are dry while other sections are wet.

Measure all qualifying pools that have water (even a trickle) flowing into and out of them. Don't measure stagnant (isolated) pools.

Collect macroinvertebrates in sites with partial flow. The rule is, if there is enough water in any part of the reach to move bugs into the net, collect them in those areas. If no fast-water habitats occur, take the samples from shallow, slow-water habitat units.

Gradient will either be collected at the thalweg or on the left wetted edge depending on if the transects at A and K are dry or wet. If either Transect A or K is wet and the other is dry, measure gradient at the thalweg of both transects.

At transect cross sections, record the right and left wetted measurements only when the channel or braid connects to the main channel or another braid that eventually flows into the main channel (don't include wetted edges for braids that don't connect to main channel or a braid that connects to main channel).

For water chemistry and water samples: measure or collect samples as close to the location outlined in the procedures, preferably in flowing water. If there isn't any flowing water, measure or collect samples in stagnant pools.

For eDNA samples in streams with literally a trickle of water, use the whirlpac to scoop water from the stream and into the sampling bottles. If the flow is so low that it isn't reasonable to collect the normal amount from the site make sure it is clearly marked on the vials how much water was collected for each replicate.

If a section of the reach is completely dry when measuring large wood, make a comment that says "Dry Channel" for that piece.

Obstructions at the waypoint

If the waypoint is located on or close to an obstruction (large culvert or log jam), move the start of the site upstream to the nearest surveyable location.

Impassible barriers

If you encounter an impassible barrier (waterfall, lake or glacier) or private land ***during site layout***, establish the end point of the survey at the barrier (Transect K). Layout the site backwards traveling downstream to Transect A.

Overlapping sites

Always survey the lowest numbered site first. Two surveys should never have shared reaches. Transect K of the downstream site will be flagged as Transect A for the upstream site when appropriate (see below).

If the downstream site 1005 overlaps more than 50% of the upstream site 1006 (Transect F), then drop site 1006. However if the site layout for the upstream site 1006 has Transect F above Transect K of site 1005, then Transect K of site 1005 will also be Transect A for site 1006.

If the downstream site 1006 overlaps more than 50% of the upstream site 1005 (Transect F), then drop site 1006. However if the site layout for the downstream site 1006 has Transect K below Transect F of the upstream site 1005, then Transect A of the upstream site 1005 will also be the Transect K for site 1006.

Small Obstructions

Occasionally logjams or other obstructions cover the stream channel making it difficult to measure cross sections at transects. Cross sections can be moved up or downstream from the transect ½ of the width category. If the width category is 8m, you can bump the cross section up or downstream from the transect 4m. If the obstruction is large and blocks numerous transects, it should be excluded from the survey. Use a stop/start survey in this situation (see below).

Stop and Start of Survey

Stop and start is a technique intended for large obstructions (i.e. passable waterfall or large/long culverts) encountered in the site that interfere with data collection or compromise crew safety. If the length of an obstruction such as a culvert or log jam is greater than four times the bankfull width category (review Table 1) for the site, the site will have to be moved so the obstruction is no longer included in the reach. For example a 160 m reach, would fall in to the 8m width category, therefore if the obstruction is greater than 32m in length the site would have to be relocated to exclude that obstruction from the reach (either upstream or downstream whichever is closest).

If there is an unsurveyable obstruction within the site, such as a large log jam, passable waterfall or culvert, stop the survey at the obstruction and restart the survey upstream of it. Attempt to measure the length of the obstruction if possible by using the tape. For culverts either walk through if it is large enough or if the culvert is small go to the upstream side of the culvert, tie the end of the bank tape around a small stick and attempt to float the tape through.

Steps to deal with this situation if encountered are as followed;

1. Begin site layout as previously described.
2. When the obstruction is encountered, measure the distance to the beginning of the obstruction. Place flagging labeled “STOP SURVEY”.
3. Determine if the obstruction is greater than four times the bankfull width category for the site. If yes, relocate the survey to exclude the obstruction. If not go to step 4.
4. Go to the upstream end of the obstruction and, at the first surveyable location, hang a flag labeled “START SURVEY.” Continue measuring up to the next transect location based on the distance from the last transect to the ‘STOP SURVEY” flag.

Table 2—List of unusual situations and appropriate actions.

Situation	Action
Culverts “CV”	
Less than 4 times Bankfull width category in length	If it **does not** interfere with data collection (a major transect does not fall on the culvert) refer to the note on culverts in the “Unusual Situations” section. If it **does** interfere with data collection, perform a Stop and Start. (Refer to Stop and Start of Survey section.)
Greater than 4 times Bankfull width category in length	Relocate start of site to nearest location where the culvert will be out of the reach.
Large Logjams “LJ”	
Less than 4 times Bankfull width category in length	Stop and Start. (Refer to Stop and Start of Survey section.) This is only used if the logjam prevents the collection of data. (I.e. if a major transect cannot be moved a reasonable distance to avoid the logjams effect on data collection.)
Greater than 4 times Bankfull width category in length	Relocate start of site to the nearest location where the log jam will be out of the reach
Impassible waterfall (for crew)	Refer to impassible barriers.
Passable waterfall (for crew)“WF”	**If the waterfall prevents collection of data, Stop and Start. (Refer to Stop and Start of Survey section.)**

Side Channels

The main channel has the most amount of flow, if flow is similar select the channel with the widest bankfull width as the main channel.

All of the following criteria must be met for a side channel to qualify:

1. A side channel is any channel separated directly from the main channel or another qualifying side channel by an island with an elevation above bankfull. Only side channels that begin and end within the site will be considered (fig 1; SC-D does not qualify).
    a. A side channel begins (and ends) at the location where it becomes separated from the main channel by an island with an elevation above bankfull (fig 1: see SC-E). SC-G is considered part of the main channel because the water is split by a gravel bar which is below bankfull.
    b. Channels that are separated from the main channel by islands lower than bankfull elevation are considered part of the main channel.
2. Only include side channels with a clearly identifiable inlet (head) and outlet (tail) adjacent to an island with an elevation above bankfull (fig 1; SC-A lacks a head). Identification of head or tail maybe unclear as the side channel may either been in process of being formed or disconnected to the main channel (or another side channel) as a result of annually varying stream flows as debris/log jams form or blowout and substrate is transported during high flows.
3. The bankfull width of the side channel must be ≥ 20% of the bankfull width category of the site (Table 3). Measure the bankfull width of the side channel at 25%, 50%, and 75% of the way up from the downstream end and enter these values into the Side Channels form on the tablet. The average will be calculated and the surveyor will have to compare that to the minimum required bankfull width based on the reach length.
4. Do not sample in tributaries. Bump transect either upstream or downstream.

How to layout side channels

1. Place a pink flag next to the orange transect flag in the main channel as well as one in the qualifying side channels and number the pink flags starting with S2 (fig 2; S1 is main channel).
    a. When placing flags in the side channel visualize the main channel transect continuing over the island to the near bank of the side channel.
    b. From the point the transect would intersect the bank of the side channel, orient the transect so that it is perpendicular to the bankfull constraints (fig. 3).
2. Flag the head and tail of each qualifying side channel with pink at the ends of the island with the channel number (S2, S3, etc.) and head or tail written on it.

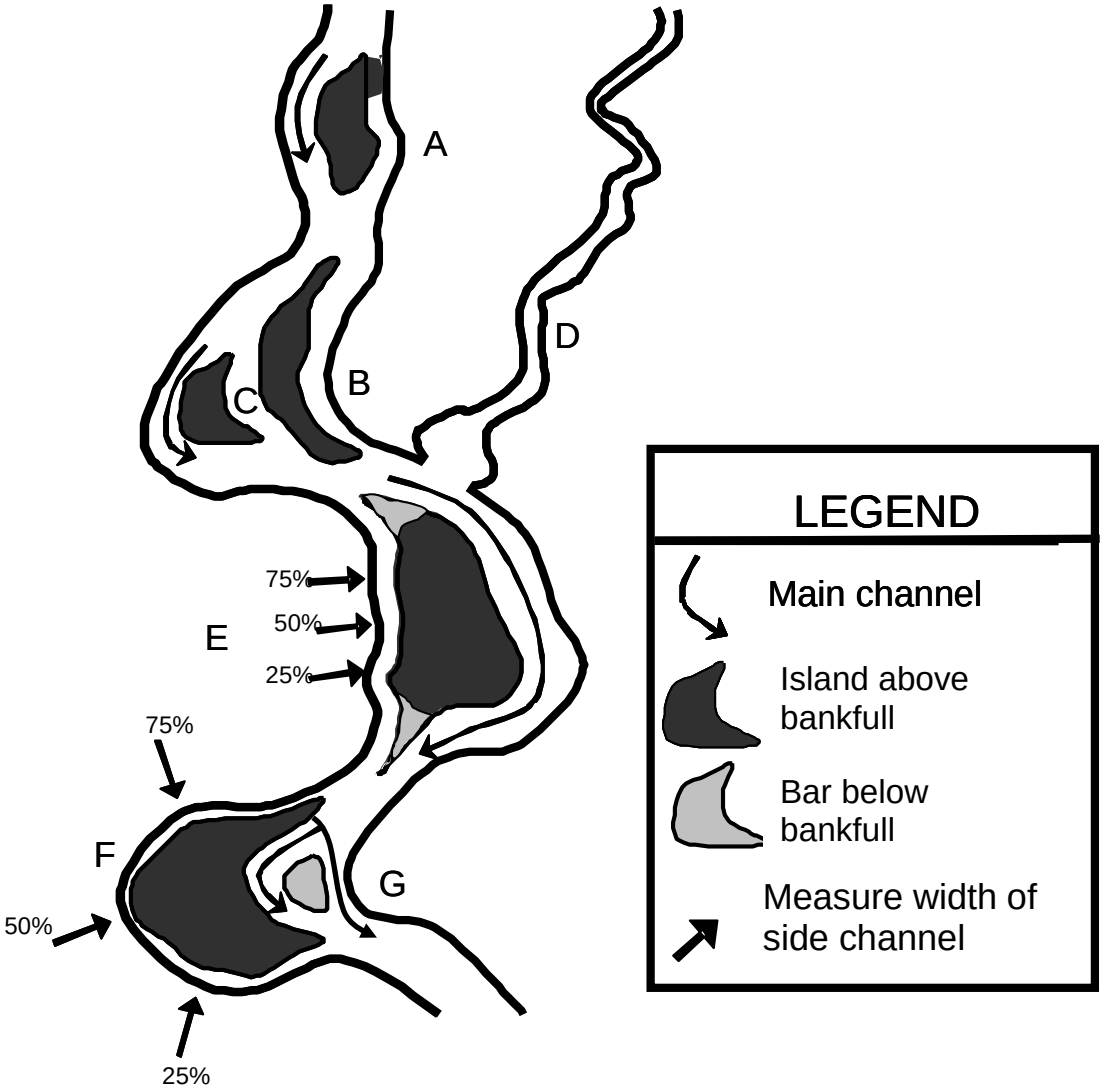


Figure 1— Examples of side channels. Channels B, C, and E are considered side channels (≥ 20% of the bankfull width category). Channel A is excluded, because it does not have a head (entry point) to the channel. Channels E and F depict where to take width measurements within potential channels (at 25%, 50%, and 75% of the way up from the downstream end of the portion of the island that is ≥ the bankfull elevation). Channel D is not included because it began outside of the site. Channel G is part of the main channel since the bar is below the bankfull elevation.

Table 3— Minimum bankfull width for qualifying side channels.

Average Bankfull Width in meters	Width Category	Minimum average bankfull width for qualifying side channel
1 to 8	8	1.6M
8.1 to 10	10	2.0M
10.1 to 12	12	2.4M
12.1 to 14	14	2.8M
14.1 to 16	16	3.2M
16.1 to 18	18	3.6M
18.1 to 20	20	4.0M
20.1 to 22	22	4.4M
≥22.1	24	4.8M

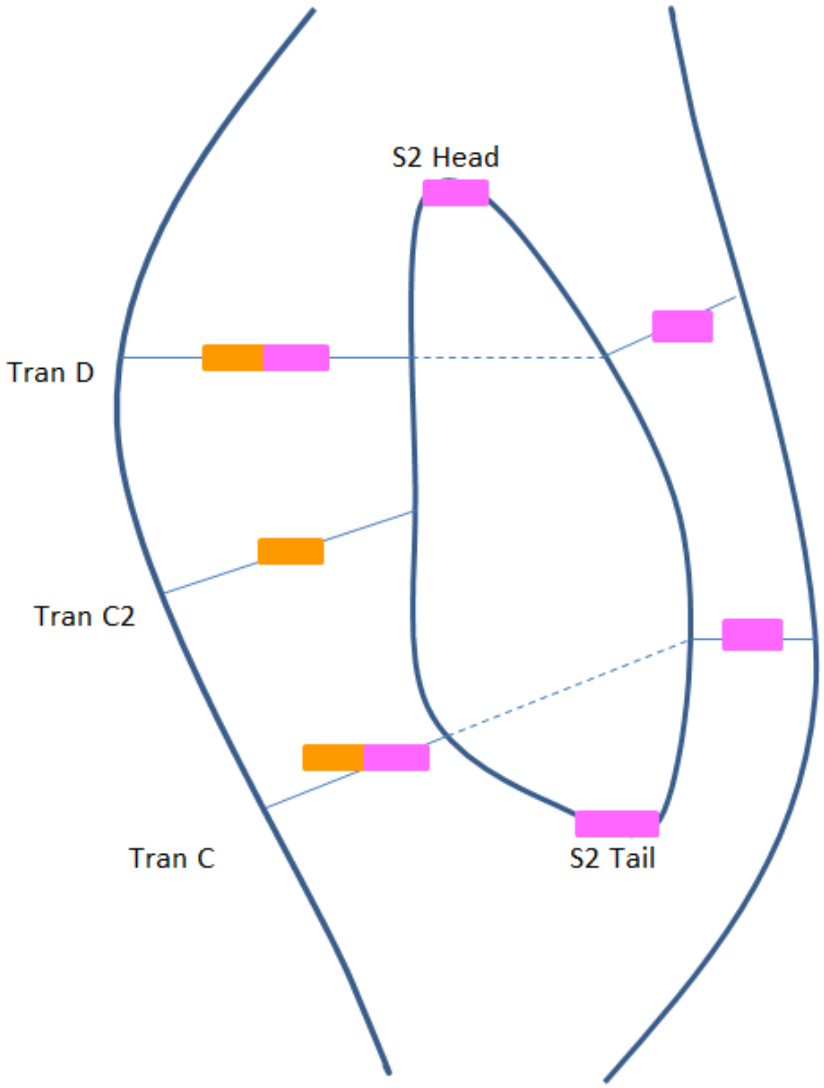


Figure 2— Placement of flags when side channels are present. Orange boxes represent where to place transect flags. Pink boxes represent where to place flags associated with the side channel. Note; no flags are placed in side channel for minor transects.

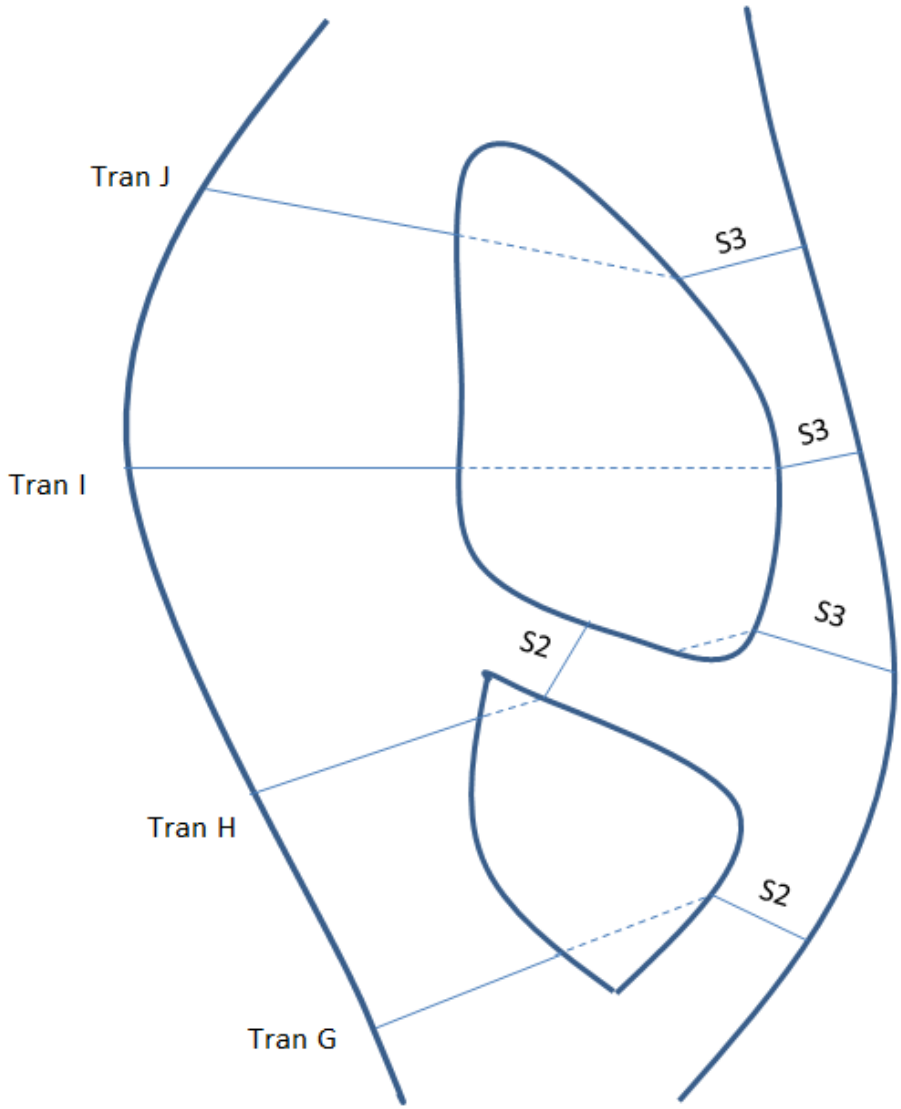


Figure 3— Transects are set up on side channels such that they are projected linearly across the island and turned perpendicular to the bankfull constraints of the side channel. Note; Tran H is projected linearly across the first island (S2) and the same linearity is carried across to the second island (S3). Flagging and minor transects on main channel were omitted to focus on linearity of placing transects in side channels.

Channel Morphology

Cross sections will be setup for each major transect. At each cross section, record bankfull and wetted widths along with depth measurements relative to bankfull. The depth measurements are relative to the bankfull line and are measured at left bankfull (which will have a depth of zero), left wetted, thalweg, right wetted, right bankfull (also a depth of zero) and points visually estimated at 10%, 30%, 50%, 70%, and 90% from left bankfull (fig. 4).

If the main channel is **dry**, collect depth measurements at eight points along the transect, which include left bankfull, deepest point in channel (where thalweg would be if water was present), right bankfull; and five equally spaced points estimated at 10%, 30%, 50%, 70%, and 90% from left bankfull.

If the channel has braided into other mini channels separated by bars – record these as multiple wetted widths and depths on the data form.

For side channels, record bankfull and wetted widths as well as depths. Collect depth measurements at left bankfull, left wetted, right wetted and right bank. If the side channel is **dry**, measure bankfull width and depths at left bankfull, right bankfull and at 25% and 75% from left bankfull (fig. 5).

Cross Section Transects

- Cross sections are perpendicular to the channel (not flow).
- Cross sections don't have to be in exactly in line with the transect flags, they can be moved up or downstream from the transect flag ½ of the width category. If the width category is 8m, the cross section can be moved up or downstream from the transect flag 4m.
- Find the most suitable location within this area, try to avoid:

Undercut banks	Brushy banks
Islands	Logs and log jams
Boulders	Uneven water surface
Bars	

Bankfull width

- Stretch a meter tape from the left bankfull elevation to the right bankfull elevation, ensuring that it is level and perpendicular to the bankfull channel. When using bank pins make sure to account for the distance from the pin to the clip when stretching the tape.
- Record the width in meters (to the nearest cm, example; 1.05m).

Depths

- Stretch a meter tape from left bankfull elevation to right bankfull elevation, ensuring that it is level and perpendicular to the channel. Secure each side of the meter tape by hand or with bank pins.

- Using the stadia rod, take depth measurements at (left bankfull and right bankfull should be zero since that is where the tape is held at) left wetted edge, thalweg, right wetted edge; and five equally spaced points visually estimated at 10%, 30%, 50%, 70%, and 90% from left bankfull. For each measurement record the height from the substrate to where the bank tape crosses the stadia rod and the distance on the bank tape (to the nearest cm).

Special Situation: If a large boulder or log is located on an increment point and the obstruction is below bankfull elevation, collect the point on top of the obstruction. If the obstruction is above the bankfull elevation, bump the increment point a little left or right to bypass the obstruction (50% might be more like 55% or 45%, that's okay).

Special Situation: If a channel is so wide that the bank tape "bows" in the middle, use the handheld laser to shoot to a target (another surveyor) standing on the opposite bankfull to get the bankfull width, do likewise for the wetted width. For the depths use the laser to shoot to where the surveyor is holding the stadia rod to take the depth measurements, the surveyor shooting the laser should not move from the bank they used to determine bankfull width. Use the surveying string to create a taut bankfull line to base the depth measurements from (Appendix B).

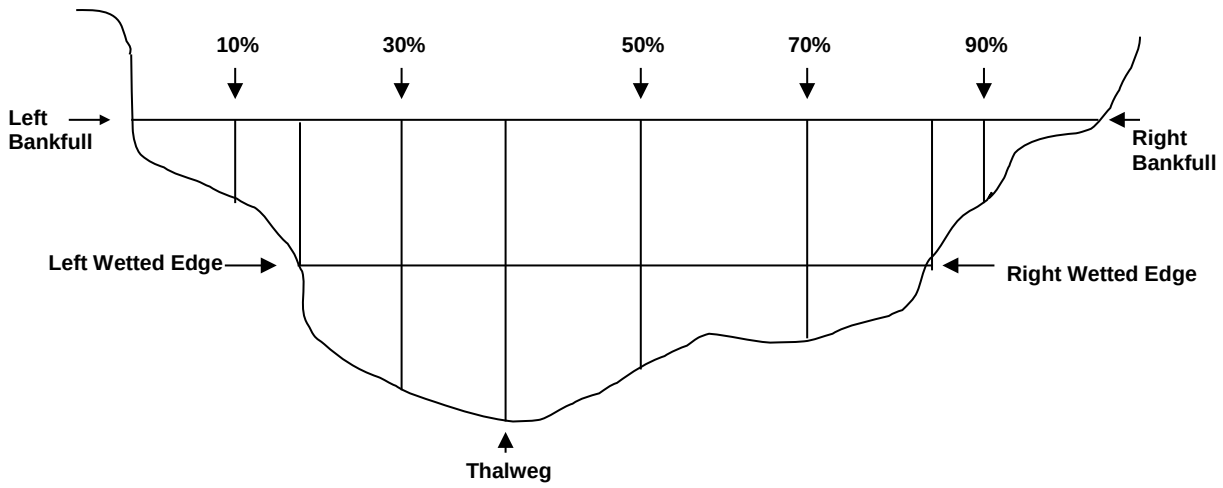


Figure 4— Example of the points measured at each major transect.

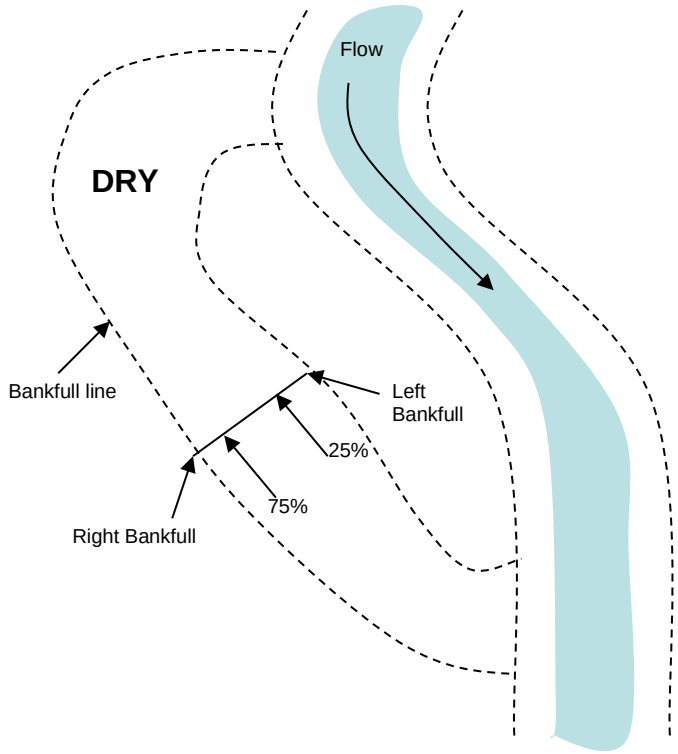


Figure 5—If the channel is **dry**, measure only the bankfull width and the depths at left bankfull, 25% and 75% of the bankfull width, and right bankfull.

Stream Gradient

The stream gradient is measured by the change in elevation measured between the left wetted at Transect A and the left wetted at Transect K (or their respective thalweg's if the reach is dry at either Transect A or K; fig 6) divided by the reach length. Since the reach length is already known, this section discusses how to measure the change in elevation between A and K.

The elevation change will be measured twice, once upstream (traveling from Transect A-K) and once downstream (traveling from Transect K-A). The second trial provides a means of comparing the relative precision of the first trial. If the difference in the elevation of the second trial is outside of the plus or minus 10% confidence interval for the first trial then a third trial is taken.

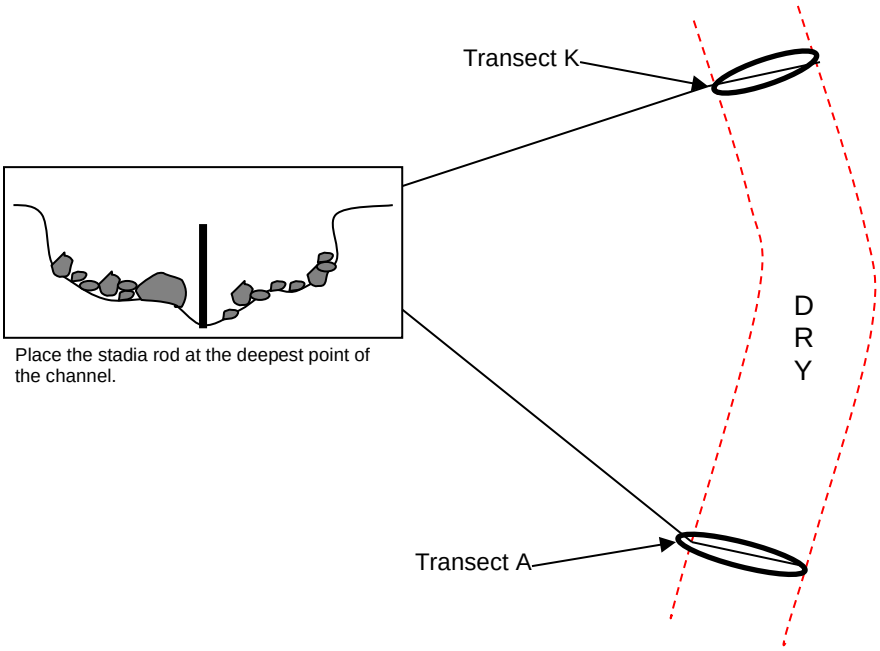


Figure 6— Example of where to place the stadia rod in the situation where the stream channel is dry at both Transect A and K.

Setting up the tripod and auto level

1. Determine a location to set up the auto level so that in addition to Transect A being within view, as much of the reach upstream is also visible to minimize the amount of measurements taken. Each measurement introduces potential sources of error whereby the tripod or stadia rod may (accidentally) not be level.

- Sometimes vegetation removal is required but waving the rod around through vegetation can help see the rod through the level.
- Sighting across land can be easier than trying to move up the stream.
- It is ok to have a negative slope for a section as long as the total reach slope is positive.

2. Extend the tripod legs and firmly set into the ground. Adjust so the legs are in a regular triangle and are set so there is no wobble.

3. Place the auto level on the base plate and tighten the center screw. Just make sure it's snug, don't overtighten.

4. Begin adjusting the legs of the tripod until the bubble is approximately in the center of the level.

5. Adjust the foot or fine screws until the bubble is exactly in the center of the circle. Be careful with these screws as if they are too tight they will break. Be EXTREMELY careful around the tripod as to keep it from falling over.

6. Gently swivel the instrument to make sure it is level in all planes.

Note: If the bubble moves out of center when the instrument is swiveled, the vial needs adjustment. To adjust the vial turn the fine screws to bring the bubble halfway to center. Using the Allen wrench, turn the two vial adjustment screws to center the bubble. Repeat this procedure until the bubble remains centered when the level is rotated 180 degrees.

Taking measurements

1. Position the stadia rod at Transect A, holding the bottom of the rod at left wet (or thalweg if dry) as vertical as possible with the numbers facing the auto level. To ensure the correct height is recorded the stadia rod should be slowly rocked forward and backward, recording the minimum rod reading (fig. 7). The true reading occurs at the minimum value when the rod is plumb (level).

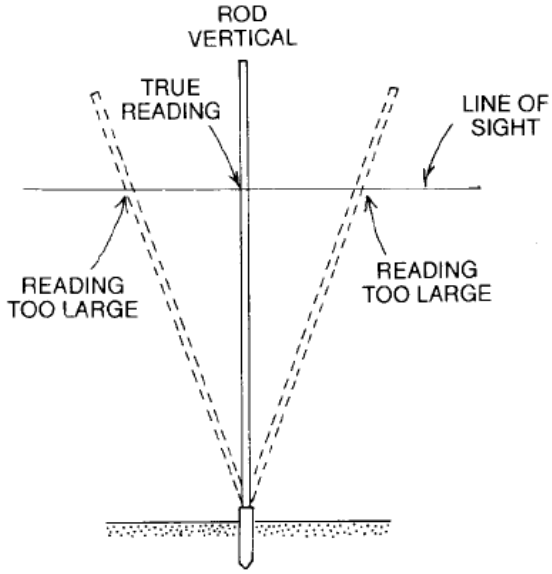


Figure 7—Diagram depicting how swaying the stadia rod back and forth captures the height of the stadia rod when level

2. Sight the stadia rod through the auto level and record the reading to the nearest 1 cm (fig. 8).

a. Stadia rods are 5 m in length and alternate between black and red 1 m sections.
b. Each 1 m section is broken up into 10 cm increments designated by a large number on the right side and a line that stretches all the way across the stadia rod.
c. Each 10 cm section is divided in half with “E” symbols that are 5 cm in length.
d. The top or bottom of each block or line in the “E” is 1 cm.
e. For the image below (fig. 8) the final measurement would be recorded as 142 cm.

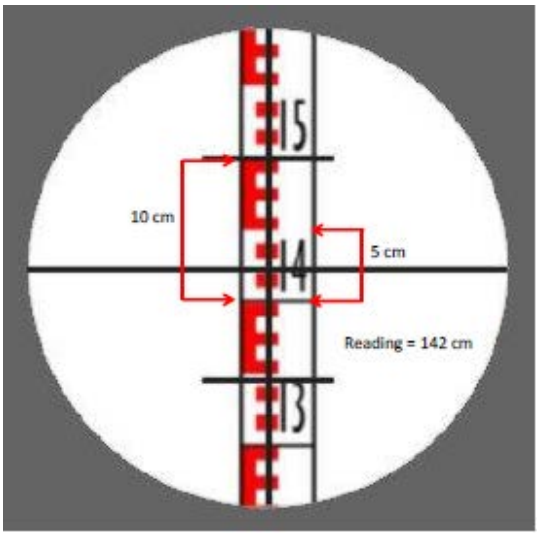


Figure 8—Stadia rods are broken up into 10 cm sections, denoted by the large number on the right. Each 10 cm section has a large "E" that is 5 cm long. Each meter section is broken up by alternating red and black section colors.

3. Move the stadia rod to the farthest location upstream that can still be seen from the location of the level, the rod does not need to be at left wet again until Transect K. Gently swivel the instrument (being careful to make sure the bubble stays inside the center of the level) to face the next reading.

4. Hold the stadia rod as before, vertically, swaying back and forth to get the level reading of the rod with the numbers facing the auto level.

5. Sight the stadia rod and record the reading to the nearest 1 cm.

6. Keep the stadia rod in the exact position as the reading before (this serves as a reference point connecting the next line of shots).

7. Move the auto level to a new position where the stadia rod can be seen as well as a new portion of the reach. Set up as before making sure the equipment is level.

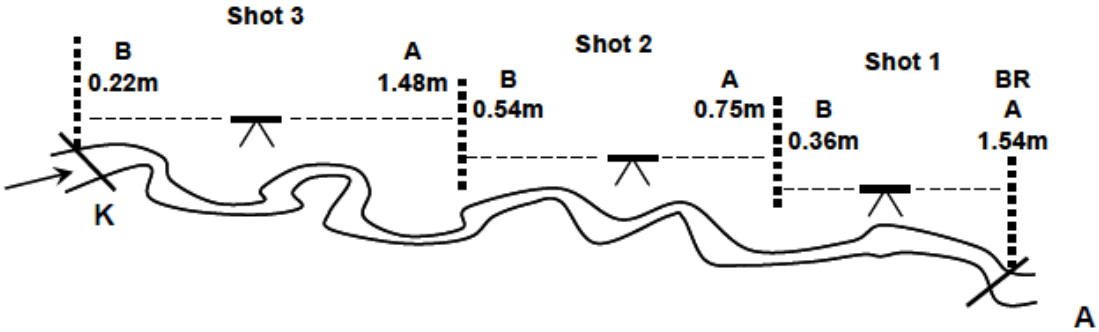
8. Back sight to the stadia rod and record the reading to the nearest 1 cm, start the new line of measurements from that point.

9. Repeat steps 3-8 until the stadia rod is sighted at Transect K, hold the stadia rod at left wet.

10. Repeat steps 1-9 via a second pass from Transect K to A to get a second total change in slope.

11. Calculate the % difference between the two readings. If it is greater than 10%, conduct a third pass (fig. 9).

Special Situation: If a large vertical waterfall is encountered within a site that is too steep to use the level and stadia rod the laser will have to be used for this section of the reach (Appendix C).



Measuring stream gradient: starting from Transect A, shooting upstream

A → K

	Shot 1			Shot 2			Shot 3			Shot 4			Shot 5			Sum of Dif (Dif 1+Dif 2...)
	A	Dif 1 A - B	B	A	Dif 2 A - B	B	A	Dif 3 A - B	B	A	Dif 4 A - B	B	A	Dif 5 A - B	B	
Elevation 1	1.54	1.18	0.36	0.75	0.21	0.54	1.48	1.26	0.22							2.65
Elevation 2	1.77	1.10	0.67	0.63	0.33	0.30	1.56	1.20	0.36							2.63
Elevation 3																

Measuring stream gradient: starting from Transect K, shooting downstream

K → A

	Shot 1			Shot 2			Shot 3			Shot 4			Shot 5			Sum of Dif (Dif 1+Dif 2...)
	A	Dif 1 B - A	B	A	Dif 2 B - A	B	A	Dif 3 B - A	B	A	Dif 4 B - A	B	A	Dif 5 B - A	B	
Elevation 1	0.29	1.13	1.42	0.48	0.16	0.64	0.41	1.08	1.49							2.37
Elevation 2																
Elevation 3																

Are measurements within 10%?

		lower limit		upper limit
Elevation 2.65	* 0.9 =	2.39	* 1.1 =	2.92
Elevation	* 0.9 =		* 1.1 =	
Elevation	* 0.9 =		* 1.1 =	

Figure 9—Calculating stream gradient using three trials. When the first two measurements are not within ±10% threshold (The 2nd trial of 2.37 is not between 2.39 and 2.92, the confidence bounds of the 1st trial), calculate elevation change a third time (2.63).

Pools

Objectives:

- Quantify the relative length and frequency of pool habitat in each site.
- Determine the average residual depth of the pools.

Pool Criteria:

Sample every pool within the sample site that meets **ALL** of the following criteria for low flow conditions.

1. Pools are depressions in the streambed that are concave in profile, laterally and longitudinally (think of a spoon).
2. Pools are bounded by a head crest (upstream break in streambed slope) and a tail crest (fig. 10).
3. Only consider main channel pools where the thalweg runs through the pool, and not backwater pools.
4. Pools span at least 50% of the wetted channel width at any one location within the pool. For example, a pool that spans 50% of the wetted channel width at one point, but spans <50% elsewhere is a qualifying pool. This is done as an ocular estimate.
5. Pool length, measured along the thalweg from the head to the pool tail crest, is greater than its width. Pool width is measured perpendicular to the thalweg at the widest point of the pool.
6. Maximum pool depth is at least 1.5 times the maximum depth of the pool tail crest.

Determine if the pool is 'full' or 'partial' (fig. 12).

- Full-channel pool – Concave shape of the pool (measured perpendicular to the thalweg) at any location is >90% of the wetted channel width.
- Partial-channel pool – Concave shape of the pool (measured perpendicular to the thalweg) at any location is between 50 and 90% of the wetted channel width.

Classify pool formation type as scour, dammed, plunge or beaver.

- Scour – formed by flow that creates a depression in the stream channel.
- Dammed – formed by the impoundment of water upstream of a channel blockage (debris jams, landslides, large wood).
- Plunge –formed by a vertical fall of water flowing over an obstruction in the stream channel such as wood, boulders or bedrock. For a plunge pool to count the maximum depth must be within 20% or less of the pool's length. Example: if the plunge pool is 10m long, then the max depth must be 2m or less from the pool head.
- Beaver – formed by a beaver dam that slows water flow and backs up the water (see Appendix D).

Note: The habitat crew during reach layout will have to write down on the pool flags what type the pool is and whether it is a full or partial pool using shorthand with the pool type first then the pool size (Beaver = B, Scour = S, Plunge = P, Dam = D, Full = F and Partial = P; a Scour Full pool would be written on the flag as SF)

Special Situations:

Measure all qualifying pools that have water (even a trickle) flowing into and out of them. Don't measure stagnant pools.

Don't measure pools in side channels

In addition to the wetted width of the channel with the pool if there are other wetted channels adjacent to the pool that are separated by a bar, they need to be taken into account when determining whether the pool spans at least 50% of the wetted channel(s). For example, an ocular estimate of the channel where the pool has the most concavity has a wetted width of 8m, a gravel bar adjacent to the pool creates another wetted channel that is estimated at 2m wide (measure the width of the second channel in a straight line across from the main channel). With an estimate of 10m of wetted width, does the concavity of the pool span at least 50% (5m) of the total 10m of wetted width? If it does, this piece of the criteria for an AREMP pool is satisfied, if there isn't at least 5m of concavity then it's not a pool.

When considering whether to lump or split two potential pools, consider them two pools if the upstream pool has a pool tail that is ≤10cm deeper than the downstream pool tail. Conversely, consider it one pool if the upstream pool tail depth is >10cm deeper than the downstream pool tail depth (fig. 11).

Taking measurements

For each pool measure (nearest cm) the pool's length, the depth of the pool tail crest and the maximum depth.

1. For each pool select the longitude, whether the pool is a "Full" or "Partial", the pool type (Scour, Plunge, Dam or Beaver). If a pool starts before Transect A or ends outside of Transect K, collect all the pool measurements (tail, max depth, and head) regardless of whether they fall outside of the reach use longitude AA or KK to denote features out of the reach.

2. Measure the water depth of the pool tail crest by placing the stadia rod at the deepest point along the pool tail crest.
    a. Measure the pool tail crest depth on dammed pools along the top of the obstruction (usually large wood) if all flow is going over the obstruction. Conversely, measure to the streambed if some of the water is observed flowing under/through the obstruction.

3. Measure the maximum water depth in the pool with the stadia rod.

4. Measure the length of the pool by holding the bank tape near the water surface at the head of the pool and hold the other end at the pool tail crest, be careful to follow the thalweg. If a sharp bend is encountered, account for this by taking multiple measurements to capture the pool length. If the pool is a plunge pool, hold the bank tape at the head crest where the plunge or cascading fall of the water hits the water's surface. If the pool "undercuts" the cascade of falling water, stretch the tape behind the cascade to include this portion in the length of the pool.

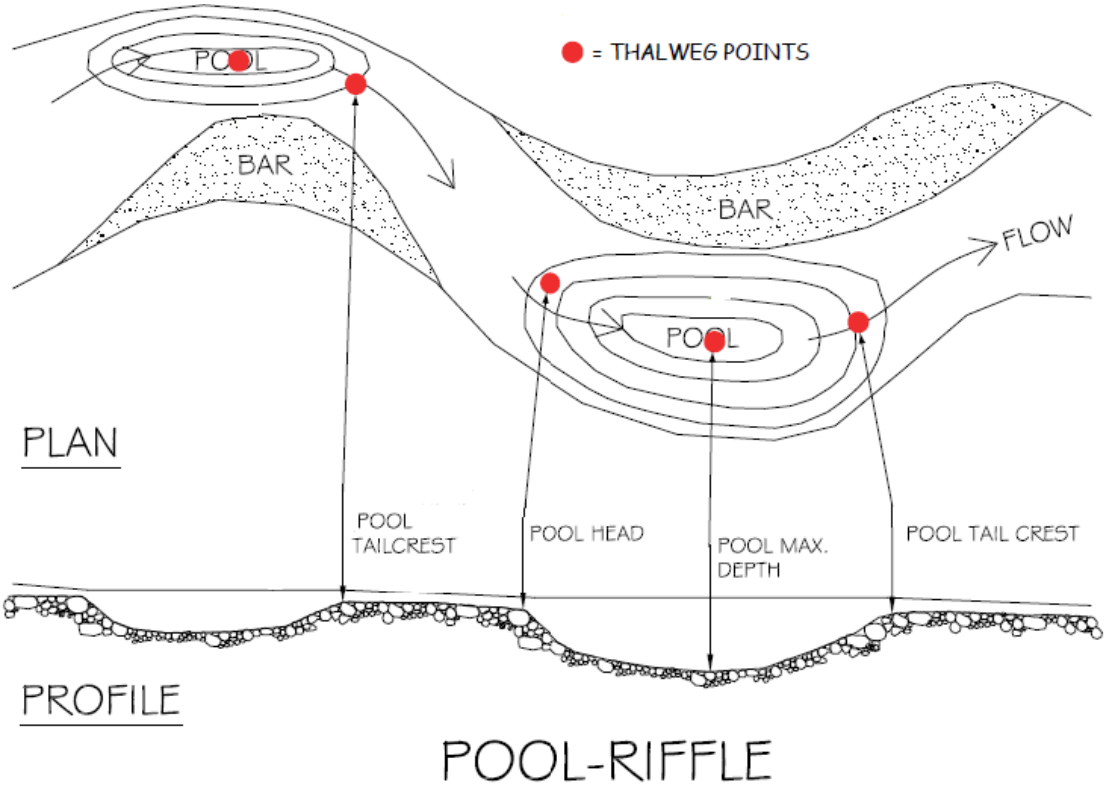


Figure 10— Diagram of pool features in a pool-riffle system including thalweg, pool head, maximum pool depth and pool tail crest.

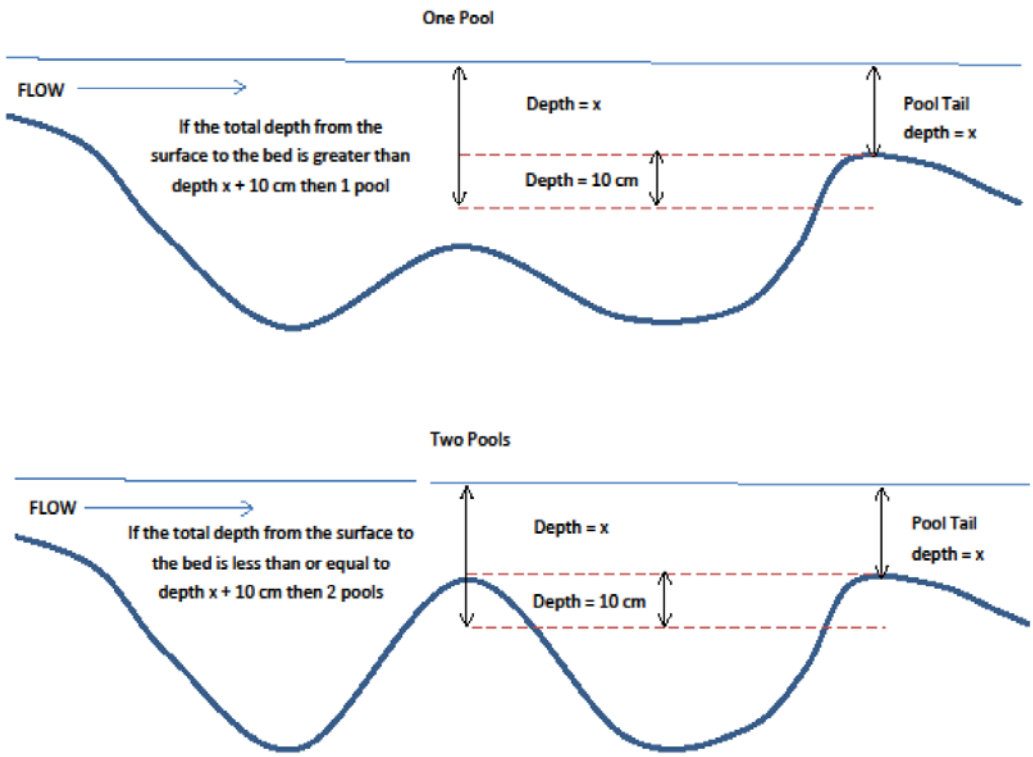


Figure 11— Example of lumping and splitting pools.

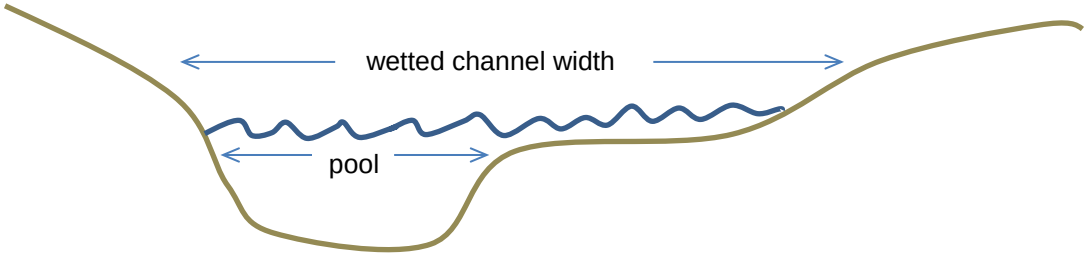


Figure 12—Pool width relative to wetted channel width. The widest point of the pool feature above is approximately 40% of the wetted channel width. Therefore this pool feature would be disqualified as an AREMP pool.

Entrenchment

Entrenchment will be determined at all sites with less than 30 m in average bankfull width and are less than 4% gradient (Table 4). Therefore, this task is one of the last tasks completed at a site.

Table 4—How to determine if a site is surveyed for entrenchment.

		Average BF width	
		≥ 30 m	**< 30 m**
Gradient	**≥ 4%**	***NO***	***NO***
	< 4%	***NO***	***YES***

Steps to determine if entrenchment needs to be checked:

1. Measure the bankfull width perpendicular to bankfull constraints at Transect A. Round the bankfull width to the nearest 0.1 meter. This number will be used to determine the location of two additional bankfull width measurements.

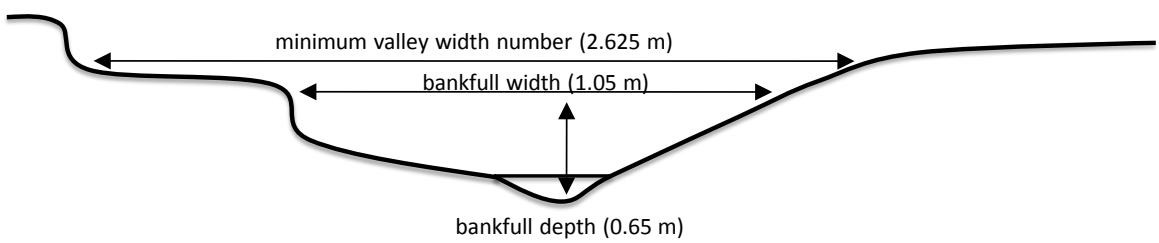
2. Two additional bankfull widths will be measured, one upstream and one downstream. For example, the initial bankfull width was 5.3 m, go upstream 5.3 m and take a bankfull width measurement. Repeat this procedure going downstream from the initial bankfull width location to get one more bankfull width measurement. If the situation arises where a bankfull width cannot be measured on the downstream end of Transect A, take the additional measurement above Transect A.

   Note: If a qualifying side channel is encountered while acquiring the upstream bankfull width, measure the bankfull width of the side channel and add it to the bankfull width of the main channel.

3. Record the three bankfull widths on the tablet and if the average is less than 30m and the site has less than 4 % gradient, entrenchment will have to be checked at Transect A. If the crew cannot measure the bankfull depth at Transect A due to deep water, move upstream to the next suitable major transect.

Entrenchment Sampling Method

1. Stretch a meter tape from the left bankfull elevation to the right bankfull elevation (fig. 13), ensuring that the tape is level and perpendicular to the bankfull channel. Record the bankfull width in meters (to the nearest cm, for example; 1.05m).
2. Multiply bankfull width by 2.5 to determine the minimum valley width number for entrenchment (*Note: This is automatically done in the Entrenchment data form*).
3. Using a meter stick or the stadia rod, measure maximum bankfull depth, from the meter tape to the substrate at the thalweg. Record the bankfull depth in meters (to the nearest cm, example 0.65m).
4. Multiply the maximum bankfull depth by 2 to determine the flood prone elevation (*Note: This is automatically done in the Entrenchment data form*).
5. At the flood prone elevation, stretch the meter tape perpendicular to the valley walls until you reach the minimum valley width number determined in Step 2. If you touch the ground of the valley wall on **both** sides, before you reach the minimum valley width number, measure and record the valley width to the nearest cm. (The site is entrenched). If you are not touching the valley wall on both sides when you reach the minimum valley width number, record the minimum valley width number. (Site is not entrenched).



Bankfull width	Minimum valley width number	Maximum bankfull depth	Flood prone elevation
1.05 m	1.05 m * 2.5 = 2.625	0.65 m	0.65 m * 2 = 1.3

Figure 13—Diagram and table depicting entrenchment calculations.

Physical Habitat

Substrate – Pebble Counts

Bed and bank materials of a stream are key elements in the formation and maintenance of channel morphology. These materials influence channel stability and resistance to scour during high flow events. The frequency of bed load transport can be critically important to fish spawning and other aquatic organisms that use substrate for cover. The procedure requires taking measurements of substrate at increments along the main channel and side channels transects within bankfull constraints.

Pebble Counts

1. Substrate will be measured at 20 transect locations (Transects A2 – K; major and intermediate transects) which may extend into adjacent qualifying side channels.
2. Transects shall be divided into five increment points visually estimated at 10%, 30%, 50%, 70% and 90% within the bankfull width starting at left bank. At each increment point three substrate samples will be collected for a total of 15 substrate samples at each transect.
3. When side channels are present at a transect, split the five increment points between the main and side channels in proportion to their bankfull widths and adjust the measurement increments accordingly. The main channel should always have the most samples. For example, if the main channel has a 10-meter bankfull width and the adjacent side channel has a 5-meter bankfull width, estimate three increment points at 25%, 50% and 75% of the main channel bankfull width and then two increment points at 25% and 75% of the side-channel bankfull width.
4. Without looking directly at the substrate of your increment location, step forward bringing your meter stick LIGHTLY (don't drop meter stick down so that it bounces off of the substrate) down to touch the substrate. Reach down to the tip of the meter stick and pick up the FIRST substrate that you touch with the tip of your finger. DO NOT LOOK while you are selecting the substrate.
5. Measure two more pieces of substrate at the same increment location, repeat step 4 and do not record the same piece of substrate multiple times. If the same piece of substrate is encountered, select another piece either from upstream or downstream (downstream when at Transect K).
6. Measure the substrate along the intermediate axis with a ruler (mm). The intermediate axis is the median side (B axis) of the rock (fig. 14); it is not the longest side (length-wise) or the shortest side (depth) of the rock. Visualize the B axis as the smallest width of a hole that the substrate could pass through.
7. If the substrate has a smooth dirt feel and is not gritty, call it silt and record it as 0.031. If it is gritty and is < 2 mm, call it sand and record it as 1. Anything 2 mm and greater should be measured and recorded. If you are unable to access the substrate due to a large piece of wood, enter wood on the Substrate data form. Only use the code if you are unable to get under the log. *Do not call it "wood" if it is a piece of bark or a twig.*
8. For large boulders, you may have to use a field tape or flip the ruler end-over-end several times to get a measurement. Any measurements over 4096 mm record as Bedrock.

9. If rocks are embedded, you may have to feel for the intermediate axis with your hand and use your fingers as calipers. If you can't find the intermediate axis this way select another piece of substrate by repeating step 4.
10. Denote whether the particle was picked form the wetted channel or if it was on a dry portion of the stream bed.
11. If it is not possible to measure the substrate, perhaps because of a deep pool. Take all of the measurements for that transect either upstream or downstream (don't move flag) to the closest surveyable location that is not on another transect. If a deep pool exists at Transect K, move downstream to collect measurements, do not go above Transect K.

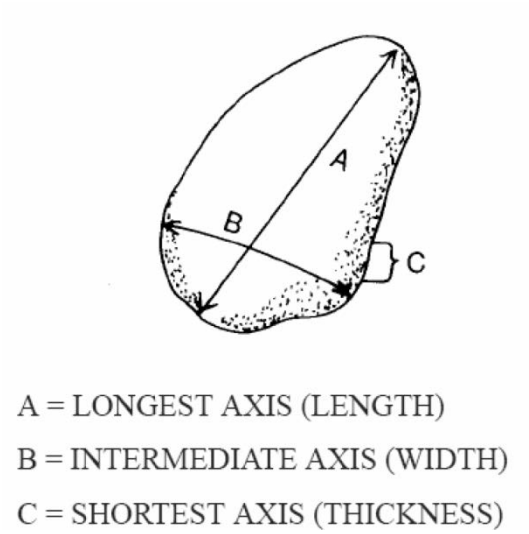


Figure 14—Axes of a pebble. The "B" of intermediate axis is measured for pebble counts (from Harrelson et al 1994).

Percent Surface Fines on Pool Tails

Objective:

- Quantify the percentage of fine sediments in the interstitial spaces of pool tail substrate for plunge and scour pools only.

Where to take measurements:

1. Collect measurements in **all pools** at each site beginning at the downstream end, including pool tails that extend below the reach. Exclude beaver or dam pools.
2. Sample within the wetted area of the channel.
3. Take measurements at 25, 50, and 75% of the distance across the pool tail crest, following the shape of the pool tail.
4. Take measurements upstream from the pool-tail crest a distance equal to 10% of the pool's length or one meter, whichever is less.
5. Locations are estimated visually.

Sampling method:

1. Assess surface fines using a 14 x 14 inch grid with 49 evenly distributed intersections. Include the top right corner of the grid and there are a total of 50 intersections.
2. For each pool record whether the pool is a Plunge or Scour Pool and Partial or a Full Pool.
3. Take **three** measurements per pool.
    a. Place the bottom edge of the grid upstream from the pool-tail crest a distance equal to 10% of the pool's length or one meter, whichever is less. Make sure that the grid is parallel to and following the shape of the pool-tail crest. (It is important to note that the pool tail crest is not always exactly perpendicular to the channel, fig. 15)
    b. Place the center of the grid at 25, 50, and 75% of the distance across the wetted channel, making sure the grid is parallel to and following the shape of the pool-tail crest.
    c. If a portion of the fines grid lands on substrate 512mm (size of the grid) or larger in size, on the b-axis, record the intersections affected as non-measurable intersections (fig. 15).
    d. In narrow streams, it is OK if grid placements overlap. If the stream is so small that part of the grid is on dry ground, count these as non-measurable.
4. Record the number of intersections that are underlain with fine sediment < 2 mm in diameter at the b-axis. The width of the cord that makes up the grid is 2 mm.
5. Aquatic vegetation, organic debris, roots, or wood may be covering the substrate. First attempt to identify the particle size under each intersection. If this is not possible, then record the number of non-measurable intersections.

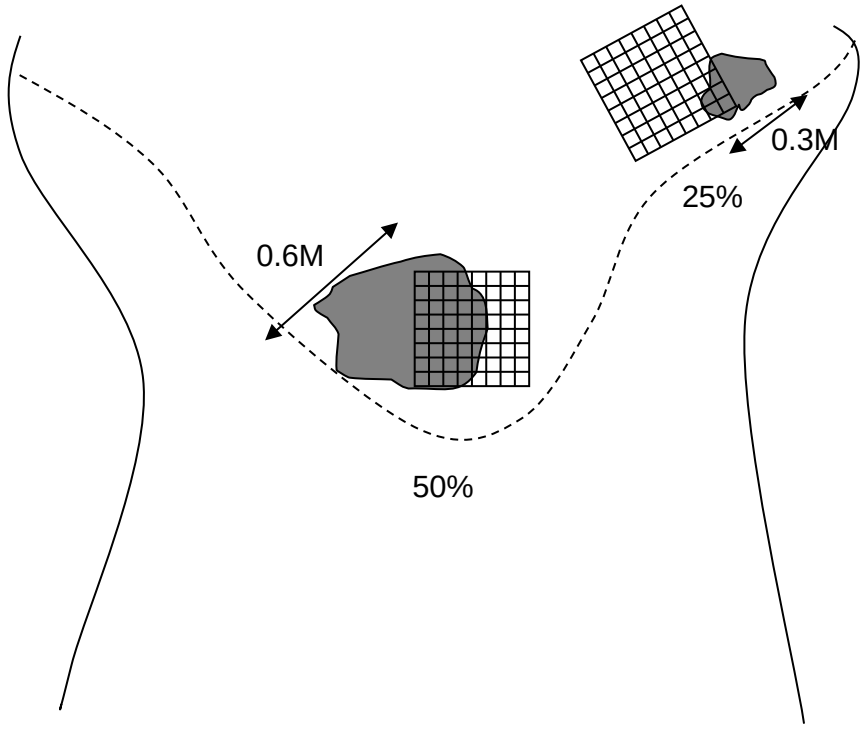


Figure 15— In this figure, all intersections of the fines grid at the 25% placement will be counted and recorded. For the 50% placement, the intersections of the fines grid that land on the boulder will be recorded as non-measureable.

Large Wood

Objective:

- Quantify the number and size of large wood pieces that are present within the bankfull channel, including qualifying side-channels.

Sampling method:

1. In order to be counted, each piece must meet ALL of the following criteria.
    a. Each piece must be greater than 3 meter in length and at least 15 cm in diameter one-third of the way up from the base, or largest end.
    b. Only include standing trees that lean within the bankfull channel if they are dead. Dead trees are defined as being devoid of needles or leaves, or where ALL of the needles and leaves have turned brown. Consider it living if the leaves or needles are green (fig. 16).
    Note: Use caution when assessing the condition of a tree or fallen log. Nurse logs can appear to have living branches when seedlings or saplings are growing on them.
    c. Wood that is embedded within the stream bank is counted if the exposed portion meets the length and width requirements (fig. 17).
    d. Do not count a piece if only the roots (but not the stem/main trunk) extend within the bankfull channel (fig. 18).
    e. Some pieces crack or break when they fall. Include the entire length when the two pieces are still touching at any point along the break (Only count as one piece if they are from the same original piece of wood). Treat them separately if they are no longer touching along the break. Count only the portion within the bankfull channel when they are no longer touching (fig. 19).
    f. Only include pieces that begin in the site, if a piece goes below Transect A it does not count.
    g. When a piece has multiple boles (trunks), measure the bole with the largest diameter when estimating/measuring.
2. Record the piece number, estimated length (nearest 10 cm), and estimated width (nearest cm) for the first 10 pieces in the site. The same person will make all estimates for a given site. Make sure to estimate each piece the same way!!!
3. A subset of pieces will be measured at sites with more than 10 qualifying pieces of wood.
    a. At all sites the first 10 pieces of wood encountered will be measured. Starting at piece number 11, measure every 5th piece of wood up to and including the 35th piece of wood. All subsequent pieces of wood will be measured every 10th piece (starting with number 45).
4. If the piece of wood designated for measurement cannot be measured safely, record as a hazard on data form; then measure the next piece of qualifying wood.
5. Measure the length of the main stem and not branches or roots. Begin measurements where the roots attach to the base of the stem where the roots are still connected.
6. Identify whether the piece is a single piece or is touching at least one other qualifying piece **within** bankfull. Those qualifying pieces that are touching are

part of a complex. The main boles (trunks) not branches need to be touching to count as a complex. Complexes will be individually numbered for a reach.

7. Identify the wood type; see Table 5 for descriptions of wood types.
8. Record whether the piece was found in a pool, riffle, pool/riffle or outside of active channel. In a dry site all pieces will be outside of active channel. Select dry channel in comments to indicate this.

If you do not encounter any wood on a longitude, check the box on the data form indicating there is no wood in that longitude.

Important: If you are the estimator make sure your method for estimation is the same for each piece. If your method changes from piece to piece you are introducing bias to the correction factor being calculated when the estimates are measured.

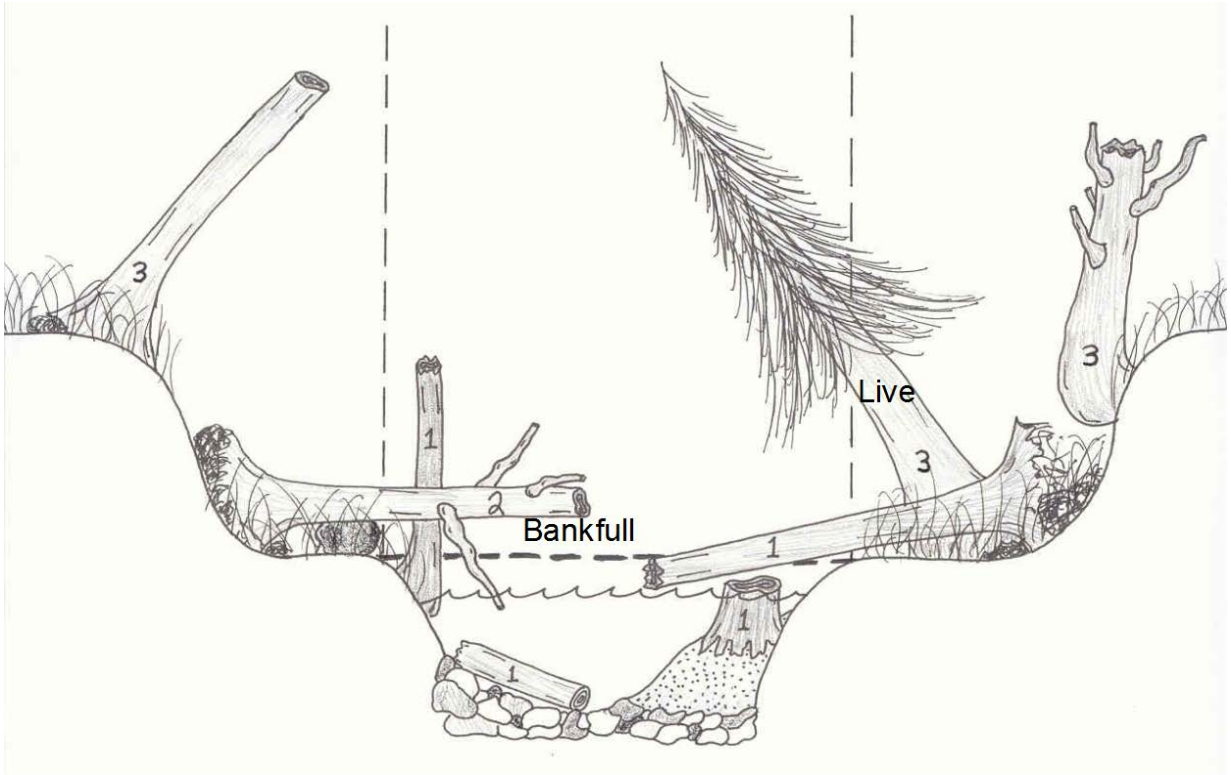


Figure 16— Illustration of large woody debris. Pieces numbered 1 and 2 would be included in the survey, while pieces numbered 3 would not be counted.

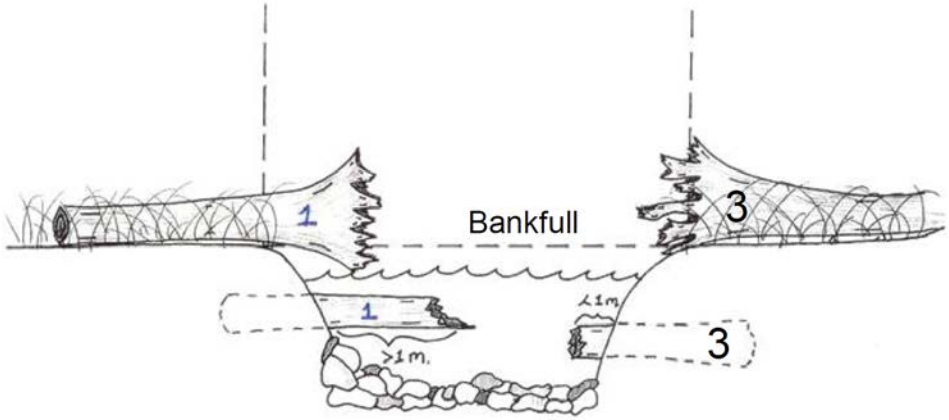


Figure 17— Examples of qualifying large woody debris (1). The pieces on the right side (3) are not counted because only the roots extend over the bankfull channel (upper) and the exposed section is < 3 m in length (lower).

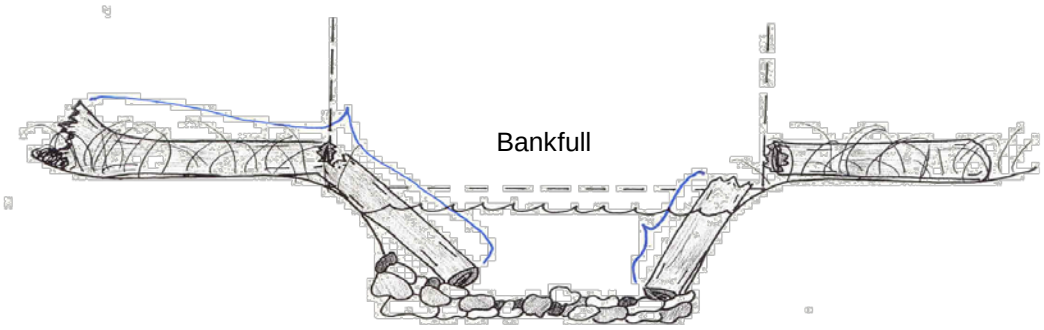


Figure 18— Examples of how to measure the length of broken pieces. Measure the length of the entire piece on the left (pieces still connected). Only measure the piece within the bankfull channel on the right.

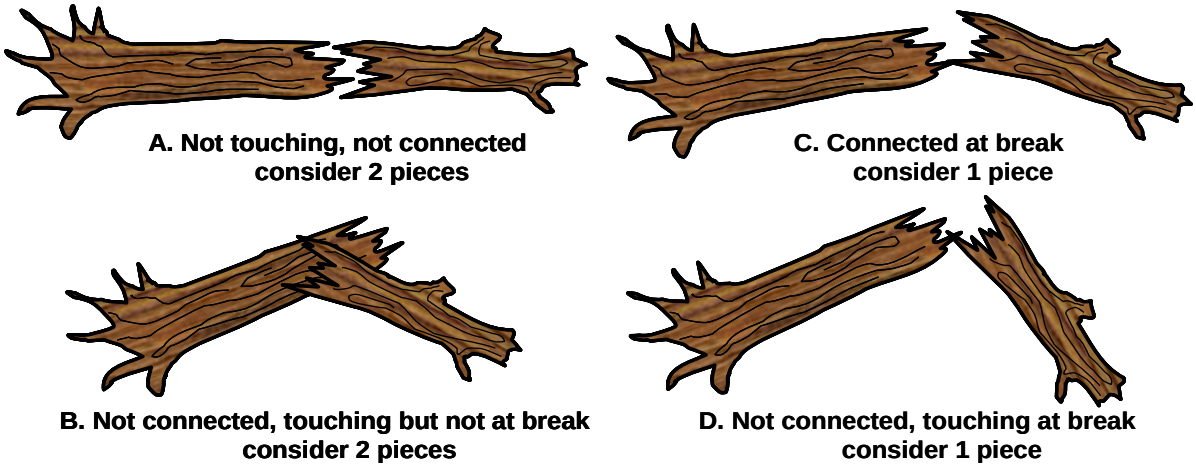


Figure 19— Variations of touching vs. not touching along the break.

Table 5— Codes used with the wood data form.

Code Type	Definition
# Pieces Touching	
S	**S**ingle piece
C	**C**omplex (> 1 piece)
Wood Type	
N	**N**atural (broken ends or entire trees)
C	**C**ut end
A	**A**rtificial (part of a man-made structure)
RN	**R**oot wad attached to trunk with **N**atural end (broken or entire tree)
RC	**R**oot wad with opposite end **C**ut

Biological Sampling

Benthic Macroinvertebrates

Sampling method:

1. Determine net placement within each habitat unit by reading the 2 pairs of random numbers on the Headings form on the tablet. The first number in each pair represents the percent upstream along the habitat unit's length. The second number in each pair represents the percent of the stream's width from river left looking downstream. Each sample will be obtained from the location where the length and width distances intersect (estimate by eye).
2. Collect samples using a 500 μm mesh net D net from fast water habitats. Take invertebrate samples from the first four fast-water (e.g. riffles, runs) habitat units. Take two separate 0.09 m^2 fixed-area kick net samples from each unit for a total of eight samples.
3. Place the kick net so the mouth of the net is perpendicular to and facing into the flow of water. Collect invertebrates from within the 0.09 m^2 sampling frame in front of the net. Work from the upstream edge of the sampling plot backward and carefully pick up and rub stones directly in front of the net to remove attached organisms. Quickly inspect each stone to make sure you have dislodged everything and then set it aside. If a rock is lodged in the stream bottom, rub it a few times concentrating on any cracks or indentations. After removing all large stones, disturb small substrates (i.e. sand or gravel) to a depth of about 10 cm by raking and stirring with your hands. Continue this process until you can see no additional organisms or organic matter being washed into the net. After completing the sample, hold the net vertically (cup down!) and rinse material into the bottom of the cup. Move to the next sample location and repeat the above procedure to create a composite sample.

Field processing method:

1. Field processing requires a squirt bottle, white plastic washtub and a 500 μm sieve.
2. Make sure you thoroughly wash organisms clinging to the sides of the net by vigorously splashing water down the net and into the cup. Then transfer the contents of the cup into the washtub using the squirt bottle to ensure the cup is completely empty.
3. Wash off any sticks and small rocks with the squirt bottle into washtub. Add water to the tub and decant invertebrates and organic matter from the sample by stirring the contents of the bucket and then pouring suspended material through the 500-μm sieve. Repeat this process until no additional material can be decanted.
4. Transfer the material in the sieve (invertebrates and organic matter) into the 2-liter sample jar by washing material from the sieve into the jar with a squirt bottle. Inspect the gravel on the bottom of the tub for any cased caddis flies or other organisms that might remain. Remove any remaining organisms by hand and place in the sample jar, fill jar with water so contents are submerged.
5. Examine the contents for non-native snails, mussels, or crayfish.

6. Remove and release from the washtub/sample jar all vertebrates, including fish and amphibians.
7. Store any Megaloptera in a separate container as they will prey upon other macroinvertebrates in the sample (fig. 20).
8. At camp, fill the jars with 95% ETOH. CLEARLY label the jars using a pencil and the labels provided. Preserve this composite sample in one or more sample jars depending on the amount of material collected. If there are multiple jars, label them as 1 of 2 and 2 of 2, etc. and then tape them together.

Special situations:
Collect macroinvertebrates in sites with beaver dams, see 'Appendix D: Sampling Sites with Beaver Activity' (simply stated we want bugs collected DS from dams).

Collect bugs in sites with partial flow. The rule is, if there is enough water in any part of the reach to move bugs into the net, collect them in those areas. If no fast-water habitats occur, take the samples from shallow, slow-water habitat units.

Invasive Species

Invasive species can have a multitude of effects on native flora and fauna. The presence of invasive species can indicate degraded watershed condition. All sites will be examined for the presence of any invasive species listed in Table 6. Incidental occurrences of any invasive plants or animals should be recorded.

Aquatic Plants

Sampling methods

1. During site layout, examine the wetted portion of the channel for any potential invasive plants. Be sure to cover the entire site, and thoroughly examine any off-channel wetted areas as well.
2. If an invasive plant is encountered, take photographs and collect specimens. Place plant specimens between two sheets of paper in a plant press (see Appendix E for plant press protocol). Label the paper in the plant press with watershed code, site number, date, species code, and personnel code. Try to keep specimens in a cool dark place to avoid rapid decomposition.
3. Record the longitude segment, the species, the jpeg number of any photographs taken, and whether or not a sample was taken of any invasive plants found.

Aquatic Animals

Sampling methods

1. During site layout, examine the wetted portion of the channel for any potential invasive animals. Be sure to cover the entire site, and thoroughly examine any off-channel wetted areas as well.
2. After obtaining eight benthic macroinvertebrate samples in the first four fast-water riffles of the survey (as described in the Benthic Macroinvertebrates section above), empty the contents of the sample collection net into a large washtub or bucket.
3. Examine the contents of the sample for the presence of any invasive snails, mussels, or crayfish listed in Table 6 and pictured in the reference material.
4. If an invasive crayfish, snails or mussels are found in the sample, take photographs and record the species code and jpeg. Preserve the specimen using 95% ETOH as described in the Benthic Macroinvertebrate section of this protocol. Label the jar with watershed code, site number, species code, date, and personnel code.
5. If invasive species are found, collect more samples at various locations in the site until more of the invasive specimens are found.
6. Place the extra specimens into a separate jar, preserve them with 95% EtOH, and label the jar with watershed code, site number, species code, date, and personnel code.

Terrestrial Plants

Sampling method

1. Terrestrial plant surveys will be performed in longitudes A-B, F-G, J-K.
2. Left and right bank on each side of the site will be examined for five minutes.
3. Crew members should start at the bankfull indicator of the upper transect (B, G, K) on opposite banks, and thoroughly examine the area downstream to the next transect that is no more than five meters in width from the bankfull indicator line. If you reach the next major transect before the five minute search time elapses, you may continue downstream, but do not pass the next major transect where a plant survey will be performed.
4. If multiple channels occur at the search location (i.e., side channels), conduct the search on the outermost left and right banks. Do not conduct searches on islands or mid-channel gravel bars.
5. Work in a zigzag pattern for five minutes, examining the riparian vegetation for any non-native plants as indicated in the species list (Table 6) and the reference material.
6. When an invasive plant is encountered, pause the stopwatch and document the plant. Record the longitude segment, species, bank the plant was found on (L or R), and the jpeg numbers. Take a GPS reading at the location of the invasive plant.
7. Re-start the stopwatch and continue the survey until five minutes have elapsed.
8. At the end of the five minutes, record the longitude, the time, and the estimated length and width of the area searched on each bank during the survey.
9. If a suspected invasive plant species is encountered, take photographs and collect specimens. Place specimens between two sheets of paper in a plant press (see Appendix E for plant press protocol). Label the paper in the plant press with watershed code, site number, date, species code, and personnel code. Try to keep specimens in a cool dark place to avoid rapid decomposition.

Terrestrial Animals

Sampling method

1. During the terrestrial plant survey and large wood surveys, crew members should examine the riparian area for any sign of feral swine.
2. Take photographs of any tracks, feces, or disturbed areas that would indicate the presence of feral swine. The most consistent indication of feral swine presence in the area are large dig outs, or disturbed areas that look similar to areas heavily grazed by cattle, but are lacking other signs of domesticated livestock in the area.
3. Record the species, location, and jpeg numbers documenting the presence of feral swine.
4. Do not collect any samples of feral swine or feces (feral swine carry diseases that can infect humans).

Incidental Invasives

If any plants or animals listed in Table 6 are found during other protocol surveys or while traveling to and from sites, be sure to document their presence on the Incidental Invasives data form. **Take photographs** of any specimens found and **collect samples** of any plants or animals that are encountered.

Table 6—Invasive species of concern

Type	Common name	Genus species	Species Code
Aquatic animals	New Zealand mudsnails	*Potamopyrgus antipodarum*	POAN
	Zebra mussels	*Dreissena polymorpha*	DRPO
	Quagga mussels	*Dreissena rostriformis bugensis*	DRRO
	Rusty Crayfish	*Orconectes rusticus*	ORRU
	Red Swamp Crayfish	*Procambarus clarkii*	PRCL
	Ringed Crayfish	*Orconectes neglectus*	ORNE
	Bullfrog	*Rana catesbeiana*	RACO
	Northern Crayfish	*Orconectes virilis*	ORVI
	Nutria	*Myocaster coypus*	MYCO
	Asian Clam	*Corbicula flumina*	COFL
	Chinese mystery snail	*Cipangopaludina chinensis*	CICH
	Big Eared Radix	*Radix auricularia*	RAAU
Aquatic plants	Yellow Flag Iris	*Iris pseudacorus*	IRPS
	Hydrilla	*Hydrilla verticillata*	HYVE
	Nonnative Milfoils	*Myriophyllum species*	MYSP
	Yellow Floating Heart	*Nymphoides peltata*	NYPE
	Giant Salvinia	*Salvinia molesta*	SAMO
	Giant Reed	*Arundo donax*	ARDO
	Brazilian Elodea	*Egeria densa*	EGDE
	Didymo	*Didymosphenia geminata*	DIGE
	Flowering rush	*Butomus umbellatus*	BUUM
	Common reed	*Phragmites austalis*	PHAU
	Curly-leaf pondweed	*Potamogeton crispus*	POCR
	Purple Loosestrife	*Lythrum salicaria*	LYSA
	Garden Loosestrife	*Lysimachia vulgaris*	LYVU
	Water primrose	*Ludwigia spp.*	LU
Terrestrial animals	Feral Swine	*Sus scrofa*	SUSC
Terrestrial plants	Japanese Knotweed	*Fallopia japonica*	FAJA
	Hybrid Bohemian Knotweed	*Polygonum bohemicum*	POBO
	Giant Knotweed	*Polygonum sachalinese*	POSA
	Giant Hogweed	*Heracleum mantegazzianum*	HEMA
	Old Man's Beard	*Clematis vitalba*	CLVI
	Garlic Mustard	*Alliaria petiolata*	ALPE
	Himalayan blackberry	*Rubus discolor*	RUDI
	English Ivy	*Hedera helix*	HEHE
	Salt Cedar	*Tamarisk ramosissima*	TARA
	Orange hawkweed	*Hieracium aurantiacum*	HIAU
	Yellow archangel	*Lamiastrum galebdolon*	LAGA

Photographs of Biota

Follow these general guidelines when taking photographs.

- Use a small object for scale (e.g., pencil, ruler).
- Avoid having people in the picture (hands or fingers are ok).
- Zoom in to capture the specimen only.
- Re-take the picture if the clarity, color, focus, angle or lighting is poor.
- It is especially important to take pictures of specimens that cannot be identified.

Amphibians, Aquatic Snails, Mussels, and Crayfish

1. Place the specimen on something that provides a good scale reference.
2. Take pictures of the dorsal and ventral sides.
3. Take pictures of any distinguishing feature about the specimen (i.e., toe arrangement, spotting/flecking, etc.).

Aquatic and Terrestrial Invasive Plants

1. Take pictures of the entire plant, including something in the picture for scale reference.
2. Take close-up (macro) pictures of different key areas of the plant that could aid in identification (i.e., flowers, leaves, stems, roots).

eDNA

The biggest challenge in collecting eDNA samples is risk of contamination and subsequently the possibility of false positive results (picking up a positive signal for a critter that isn't really there). Contamination can occur in every step in the field that deals with the filter, especially when transferring the filter to the vial. Humans are the biggest vector for contamination from one location to another because target DNA can be carried unintentionally on our hands, boots, and waders. Walking around where we are processing the eDNA sample and touching the ground, boots, waders, gloves or ungloved hands may cause contamination. For example, putting on a pair of gloves and then touching waders when the gloves slip or whacking a mosquito on our forehead with gloved hands render them contaminated. Gloves are used as a precautionary measure to prevent contamination. Do NOT spray sunblock or insect repellant near eDNA filter stations. Ultimately, we are trying to avoid contamination across locations and, hence, it is better to be ultra-cautious.

<u>Sampling method:</u>

1. You will take three samples at each site above transect K. Determine exactly where you will take sample so that you walk and work downstream of that point. Do not walk above of where you will take sample so you do not contaminate it.

2. Set up pumping station. Connect tube to filter flask and to hand pump. Make sure arrow on hand pump is pointing to vacuum setting. Put black stopper on top of filter flask and add adapter so that filter funnels will fit.

3. Carefully remove filter funnel from baggie by breaking precut opening and removing colored stopper. Place on top of adapter which is on top of stopper and filter flask. Discard the filter lid.

4. You will collect three samples of 3L of water volume at each site. For each site, you will have three vials with three different filters at the end of the day. For each sample, you will collect 1L at a time using a different whirlpac for each liter. Collect your first liter of water using NEW gloves and pour it into filter funnel and begin pumping. You will know you have a vacuum because the values on the pump will move from zero. Maintain a vacuum for the whole liter by pumping every once in a while and seeing that it is below zero.

5. Remove water in filter flask after each liter. Be careful to not overflow the filter flask because you can contaminate filter if you forget to pour water out. The filter flask only fits 1L of water and it will overflow into the tube if you forget. If this happens disconnect tube, pour out water, but always be sure that you are careful not to contaminate the filter when you have to break the vacuum seal.

6. For each subsequent liter, get out a NEW whirlpac and NEW gloves. You will collect 2 samples in the thalweg (quicker moving water near center of channel) and 1 sample in pool water.

7. Pumping can be slow for turbid samples. Be patient. Make sure all liquid has passed through filter before removing. You want the filter to be dry so that you do not miss any DNA. Be sure it is dry. Wait an extra ½ minute after you think it is dry before you begin to remove filter.

8. STAND UP TO REMOVE FILTER. Once standing, put on new NEW gloves and have CLEAN tweezers handy. Remove sides of filter funnel with gloved hand. Filter will stick to bottom of filter holder because it has been under a vacuum. Use tweezers to pull up filter from edge. Roll filter gently with hands like a flute and place it in vial. Make sure you close cap tightly on vial by screwing blue cap closed. For replicate samples R2 and R3, start at step 5.

9. Fill out eDNA section in the BioInfo tab. Store vials in soft cooler at site on ice. Keep samples cool while at site and put on dry ice immediately when back at vehicle.

11. Discard gloves and plastic filter funnel materials and put other materials away. At camp label vial. Example: ORRCK1001, MFP01, 3L, 04/27/16, R1.

Water Quality

pH, Specific conductance and Temperature

Test the YSI each day for pH and specific conductance accuracy. For pH place the probe in both the pH 10.01 and pH 4.01 calibration solutions (rinse probe between solutions). If either of those readings are off greater than plus or minus 0.1 from calibration solutions, conduct a full three point calibration starting with pH 7 (Appendix F).

For specific conductance submerge the probe in 1413 µS solution, if the reading is of plus or minus 14 µS (or 1% of solution if different from 1413 µS) it needs to be calibrated. Before doing so verify the specific conductance reference temperature is set to 25°C and the specific conductance temperature coefficient value is 1.91% (see manual on tablet). If both of these values are correct then the probe needs to be calibrated (Appendix F).

<u>Sampling method:</u>

1. At Transect F standing mid-channel, in flowing water, if flowing water is not present at Transect F take the measurements at the nearest location/transect that does have flowing water (avoid pools), lower the probe into the water to a depth of 0.5 m below the water surface. If water depth is < 1 m, take measurements at mid-depth.

2. Avoid contacting the stream bottom with the YSI, as the instrument is delicate. Wait for the readings to stabilize.

3. Record the pH, specific conductance (µS), and temperature (C°).

At the end of the day: The instrument is supplied with a grey storage sleeve that slides over the probe guard. The sleeve is used for short-term storage (less than 2 weeks). Be sure to keep a small amount of moisture (clean tap water) on the sponge in the sleeve during storage. The moistened sponge in the sleeve provides a 100% water saturated air environment which is ideal for short-term sensor storage.

Total Nitrogen and Phosphorus

1. Obtain a 50 ml centrifuge vial (new or acid washed) and rinse it with stream water three times. Be careful not to overly disturb the stream bottom which may increase suspended solids and contaminate the sample.

2. Using the 50 ml vial, collect water sample at Transect F in flowing water. If flowing water is not present at Transect F go to the next closest location with flowing water. Fill the vial about 75% full (38 ml) which leaves enough head space in the vial to allow for freezing.

3. Fill out water quality label with the creek code date and personnel code written in the following format: ORABC1009, May 06 2014, MFR01. Make sure to spell out the month and keep two digits for the day.

4. Place label on outside of vial. Tape over label with clear packing tape to protect writing on label.

5. Immediately after collecting and labeling, place the sample on ice. If in the field for longer than 24 hours, the sample must be frozen using dry ice.

Note: If reach has partial or intermittent flow place sonde and collect the water sample where water > 10cm deep and > 1 m^2. If no location exists, do the best you can to take the measurements and record appropriate comments about the quality of the sample. If there is a beaver dam/pool at Transect F place sonde/collect sample at Transect A, if beaver dam/pool is present at Transect A, place sonde/collect sample below the dam/pool even if it is downstream from the reach.

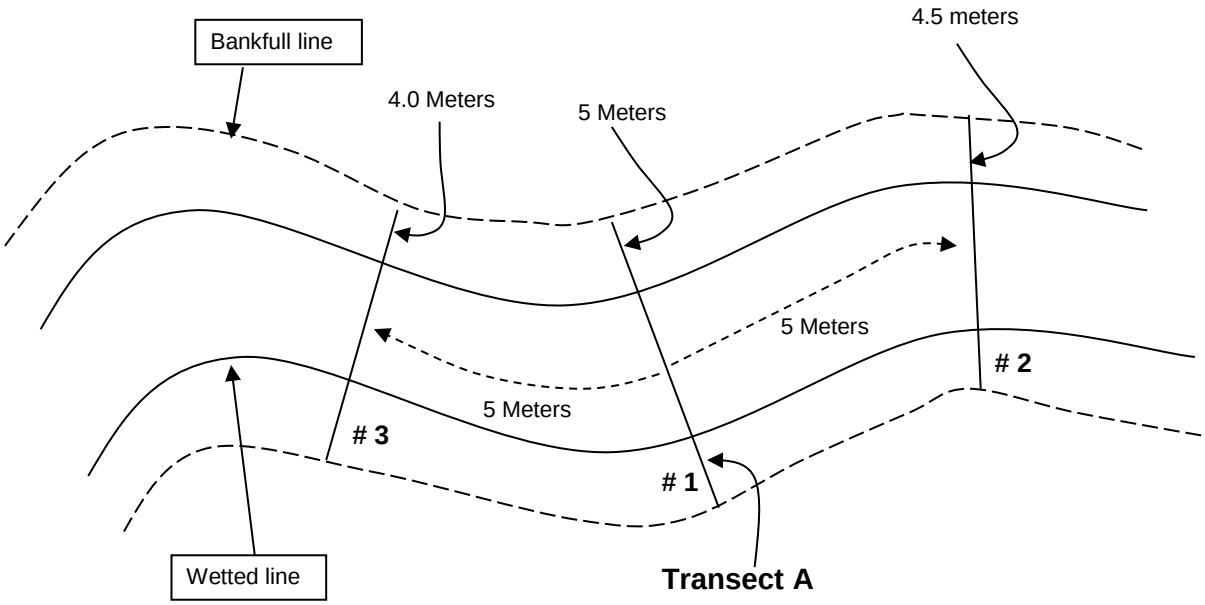
Appendix A – Reach Determination for site not previously surveyed

1. Measure the bankfull width perpendicular to bankfull constraints (not channel) at Transect A (fig. 24). Round the bankfull width to the nearest 0.1 meter. This number will be used to determine the location of two additional bankfull width measurements.

2. Two additional bankfull widths will be measured, one upstream and one downstream. For example, the initial bankfull width was 5.3 m, go upstream 5.3 m and take a bankfull width measurement. Repeat this procedure going downstream from the initial bankfull width location to get one more bankfull width measurement. If the situation arises where a bankfull width cannot be measured on the downstream end of Transect A, take the additional measurement above Transect A.

Note: If a qualifying side channel is encountered while acquiring the upstream bankfull width, measure the bankfull width of the side channel and add it to the bankfull width of the main channel.

3. Record the three bankfull widths and calculate the average. Use the average to determine the width category (Table 7 - this information is also provided on the Tablet). The site length is defined for each width category and is equal to 20 times the bankfull width category.



Measurement 1	5.0M
Measurement 2	4.5M
Measurement 3	4.0M
Add the 3 measurements and divide by 3	13.5/3=4.5
Take the average number and find the site length in Table 9	160M

Figure 24 — Schematic of the three bankfull measurements taken to determine site length and an example of how to calculate site length.

Table 7— Average bankfull width categories with corresponding site length.

Average Bankfull Width in meters	Width Category	Site Length in meters
1 to 8	8	160
8.1 to 10	10	200
10.1 to 12	12	240
12.1 to 14	14	280
14.1 to 16	16	320
16.1 to 18	18	360
18.1 to 20	20	400
20.1 to 22	22	440
≥22.1	24	480

Appendix B – Using the Laser Rangefinder for Cross Sections

Powering on and off

1. To turn the laser on, press the button closest to the back (where the screen, battery tube cap, and cable are located) of the laser on either side.
2. To turn the laser off, simultaneously press the middle and front buttons on the left hand side of the laser (fig. 25).

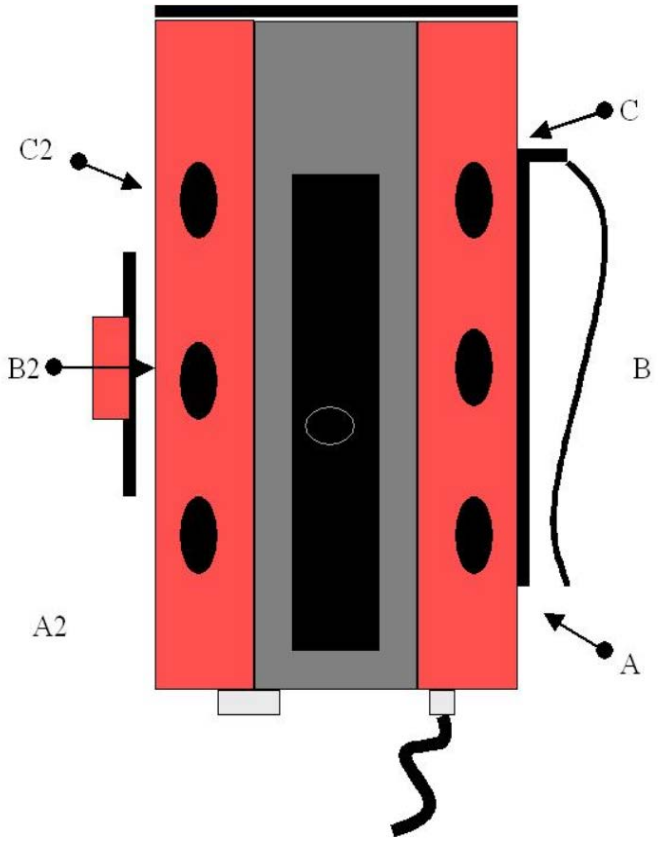


Figure 25— Button panels for the LTI 200 laser rangefinder.

Laser Display

Once the laser is turned on, the following should be visible on the LCD screen (fig. 26):

- "**Right**" in the upper left corner of the screen,
- "**HD**" in the upper center of the screen,
- "**Auto**" in the lower left corner of the screen, and
- "**M**" in the right central portion of the screen.

Important: It is very important that these four indicators are present. Absence of these four indicators or different messages will produce data not suitable to this project.

The button panels

The primary button panel (fig. 26) is indicated in the upper left hand corner of the LCD screen (fig. 26). “Right” indicates the right panel is primary and the left is secondary; this is the common setup. Specific button functions are affected by the length of time the button is depressed. A “short” press means the button is pressed and released immediately and a “long” press means the button is depressed for about two seconds before being released.

For simplicity, the buttons on the primary panel will be called “A”, “B”, and “C” (fig. 25), these buttons are located on the right hand side of the laser. The **A button** is located to the rear of the laser (closest to the operator). The **B button** is the center button and the **C button** is located to the front of the laser. The secondary button panel will follow the same button sequence, but be known as “**A2**”, “**B2**”, and “**C2**”. The button functions are described in Table 8.

Taking a measurement

To take a measurement, press the rear right button (**A**, fig. 25) once to turn on the laser dot in the scope (if not already present). Press the “A” button again to take the measurement. A beep will sound when the measurement is taken. The number displayed in the center of the LCD screen is the horizontal distance to the target. **Check the horizontal distance** to ensure the readings are logical.

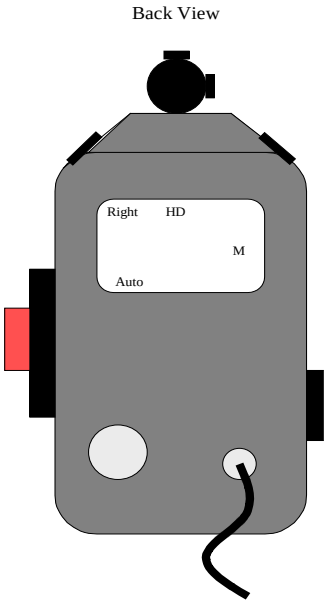


Figure 26—The LCD screen of the laser showing the correct settings for using the laser.

Table 8—Laser button functions for the LTI 200 laser rangefinder.

Button	Function
A	Powers on the laser. Turns on the red dot in laser scope and fires the laser. Selects the option listed in submenus (HT, GATE, MULTI, SYS). In system setup functions, selects or toggles values. In edit mode, accepts a manually entered value.
A2	No function in measurement operations. In system setup functions, invokes optional “edit mode” so a value can be entered Once in edit mode, advances to the next digit.
B	Moves “forward” in the menu. In edit mode, the first press restores the edit value; the second press abandons the edit. Toggles between HD (horizontal distance) and VD (vertical distance).
B2	Adjusts the brightness of the dot in the sighting scope. When pressed simultaneously with C2, turns off power. In edit mode, increments the digit value.
C	Moves “backward” in the menu, selects the previous option or backs out of the menu. In edit mode, first press restores the edit value, second press abandons the edit. Long Press: clears out the current measurement value. Toggles between HD (horizontal distance) and VD (vertical distance).
C2	Turns the screen backlight on or off. In edit mode, decrements the digit value. When pressed simultaneously with B2, turns off power.

Selecting the measurement units

The laser can express both English and metric units. Units are indicated in the right-hand central portion of the LCD screen. A displayed “M” means the units are set to metric, while a displayed “F” means the units are in feet. **Metric units should always be used and are set as the default**. The following procedure should be used **only if** the units have been accidentally changed, use this procedure to return the laser to the correct settings.

1. Press **“B”** or **“C”** to display the **SYS** indicator.
2. Press **“A”** to select the **SYS** option.
3. Press **“B”** until the **UNITS** indicator at the bottom center of the LCD screen begins flashing, and **SEL** shows in the numeric display area.
4. Press **“A”** to toggle between the **F** (feet) and **M** (meters) indicators.
5. Press **“B”** to select the M indicator. The **D** (degrees) or **G** (gradient) indicator will begin flashing.
6. Press **“A”** to toggle between **D** and **G**.
7. Press **“B”** to select **D**. The % indicator flashes, and **OFF** shows in the numeric display.

8. Press **“C”** multiple times to accept the new settings and back out to the main display.

Important: Changing the units in the laser will not change the units on previously stored data. Those points must be shot again.

Error messages

Error codes are displayed in the central area of the screen. If an error occurs, a low-pitched tone will sound and an error code will be displayed. Most errors are trivial and require repositioning and/or shooting the point again. Error codes and explanations are presented in Table 9.

Important: If the laser “freezes up” and all of the symbols are showing on the display, turn the unit off and place it in a cool shady place. After, 15 minutes or so, re-attach the laser and turn the unit back ON to see if has become “unfrozen”. If that fails, contact your field coordinator for a replacement, but keep attempting to use the laser in the meantime.

Table 9— LTI 200 Laser rangefinder error codes and their meanings.

Code	Explanation
doF	Display overflow. Distance or measurement angle too large.
EoF	Editor overflow.
E01	Failure to lock on target. Reposition and retake measurement.
E02	Target lost during measurement. Reposition and retake measurement.
E03	Unstable aim. Steady the instrument and retake measurement
E04	Invalid tilt sensor reading. Contact Laser Technology if persists.
E05	Tilt reading outside limit on height measurement. Reposition or retake measurement.
E06	Tilt calibration error. See company manual and contact your supervisor.
E52	Temperature too hot. Stop operation.
E53	Temperature too cold. Stop operation.
E60, E61, E62	Calibration or code memory checksum failure. Contact Laser Technology.

Quick reference for trouble shooting laser problems

Note: When a button is inadvertently pushed on the laser, the settings can change and become inappropriate for use in data collection for this project. Here are a few things that may need to be changed to get the laser back to the proper data collection screen (Table 10).

Using the Filter Option

1. **Press C** twice to get to the *SYS* option.
2. **Press A** to select the *SYS* option. The filter indicator will blink and ON or OFF will be shown in the center of the screen.
3. **Press A** button to toggle between ON and OFF. Press C multiple times to toggle back to the main display. The FILTER indicator will be displayed on the screen.

Turning the Beeper On and Off

1. Use **B** or **C** as needed to display the *SYS* indicator.
2. **Press A** to select the *SYS* option.
3. **Press B** until UPDATE flashes at the bottom of the screen.
4. **Press A** to toggle the beeper on or off. When turned off, the backlight sign (a sun type symbol) flashes three times and reads “off”. When the beeper is turned on, it will beep three times and reads “on”.
5. **Press C** twice to accept the setting and return to the main menu.

Checking Battery Voltage

The battery voltage level can be checked using the laser. To do so enter the SYS menu then scroll to the BATT option. The numeric display shows the current voltage reading of the batteries.

Table 10— Laser Trouble Shooting

Your Problem	Solutions to Try
The laser will not power on, or powers off immediately.	Change the batteries and check to make sure they are inserted correctly (positive end toward the front of the laser. The laser should be within tolerable temperature range (-22°F to 140°F).
When taking a distance measurement, the value is either much too small or much too large, or does not appear at all.	The screen on the laser should show an M to the right and the HD indicator in the upper section of the screen. If HD is not present, use the center or front button (A or B) to toggle to it. If the M is not present, use the quick reference guide to set the distance units. There should also be no obstructions in the path of the laser.
The laser screen shows some strange numbers and/or symbols that usually do not appear.	Press the front right button (A) until the usual HD screen appears.
When attempting to shoot the laser, the beep will sound and a distance taken, although the dot does not appear in the scope. Or, the aiming dot can hardly be seen or is too bright.	The left center button (B2) adjusts the brightness of the aiming dot. There are six dot intensities that can be accessed through repeatedly pressing this button.
When any of the buttons are pressed, nothing happens.	If the display screen shows a Lob, the batteries are nearly dead and the buttons have locked as a result. Change the batteries.
The buttons are reversed. The buttons on the other side of the laser perform the usual functions.	In the upper left hand corner of the screen should be an indicator (RIGHT or LEFT) that tells on what side the buttons are primary. To switch sides, consult the factory's user's manual.
The laser takes the measurement but does not beep.	The beep function has been turned off. Consult the Laser Quick Reference above.
When the dot is aimed directly at the stadia rod no measurement is taken and/or and E01 message is displayed.	This usually happens when the filter is turned on. Try aiming 1 to 2 inches high on the stadia rod. Also make sure no obstructions are blocking the path of the laser. Consult the Laser Quick Reference above to turn off the filter.
When firing at short and/or long distances the laser will not allow a measurement to be taken.	Make sure the stadia rod is visible. Also, check that there are no Gate measurements set (consult Laser Quick Reference above).
The distance from the laser will not enter into the data recorder.	Make sure all wires are connected, remove and plug them in again to be sure. On the bottom right corner of the screen, make sure AUTO is displayed, if not consult the manufacturer's user's guide.

Measuring bankfull widths and depths with the Laser

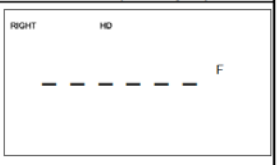
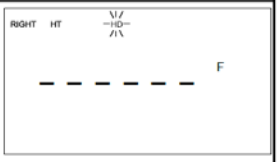
If a channel is so wide that the bank tape “bows” in the middle, use the handheld laser to shoot width distances and a surveying string to assist with depth measurements.

First, find left bank and string the surveying string from left bank to right bank ensuring the string is taut. Shoot the laser to right bank while standing on left bank to get the bankfull width. Then without the laser moving, shoot to where the other surveyor is holding the stadia rod to take the depth measurements (10%, 30%, 50%, 70%, 90%, thalweg, and right bank). Record the distance measurements at each increment from the laser and the depth measurements (from the taut string to substrate) collected by the stadia rod surveyor.

For consistency, shoot the same place on the stadia rod each time or aim for the surveyor’s hard hat.

Appendix C – Measuring Gradient with Laser

In order to capture the elevation change associated with a waterfall the laser rangefinder will be used to measure the height of the waterfall. At the conclusion of a set of down and up shots to the stadia rod go to the exact position of the stadia rod with the laser in hand. Make sure the distance from the base of the waterfall and to the last stadia rod position isn't too close or the angle for the laser may be too steep. Follow the procedures outlined below treating the waterfall as the target/object referred to in the instructions.

Button/Action	Result (example)
Press Fire to turn on the instrument	
Press Back to reach the Height indicator	
Press Fire to advance into the height subprocedure	

Button/Action	Result (example)
Sight the target through the scope	
Press Fire to take the horizontal distance measurement	
Aim to the base of the object (even if you can't sight it), and press Fire to take the base inclination reading	

Button/Action	Result (example)
Aim to the top of the object (even if you can't sight it), and press Fire to take the top inclination reading	
Press Fire to display the height of the object	

Remember to record the height in cm (the above example shows feet, verify it's in meters), for example 32.93 meters would be 3,293 cm. In the gradient data form the down measurement would be 0 and the up measurement would be 3,293. Safely navigate around the waterfall and have the stadia rod start at the safest location near the top of the waterfall and resume surveying as normal prior to the waterfall. Going downstream for the second trial, the same procedure will have to be followed.

Appendix D – Sampling Sites with Beaver Activity

Setting Up Your Site
Follow standard protocol for site layout with the following exceptions:

- Placing Transect Flags in Beaver Pools
    - Place transect flags perpendicular to the thalweg of the beaver pool if you can identify thalweg (A in fig. 27).
    - If you cannot locate thalweg in the beaver pool, place transect flags perpendicular to the beaver pool's center line (B in fig. 27).

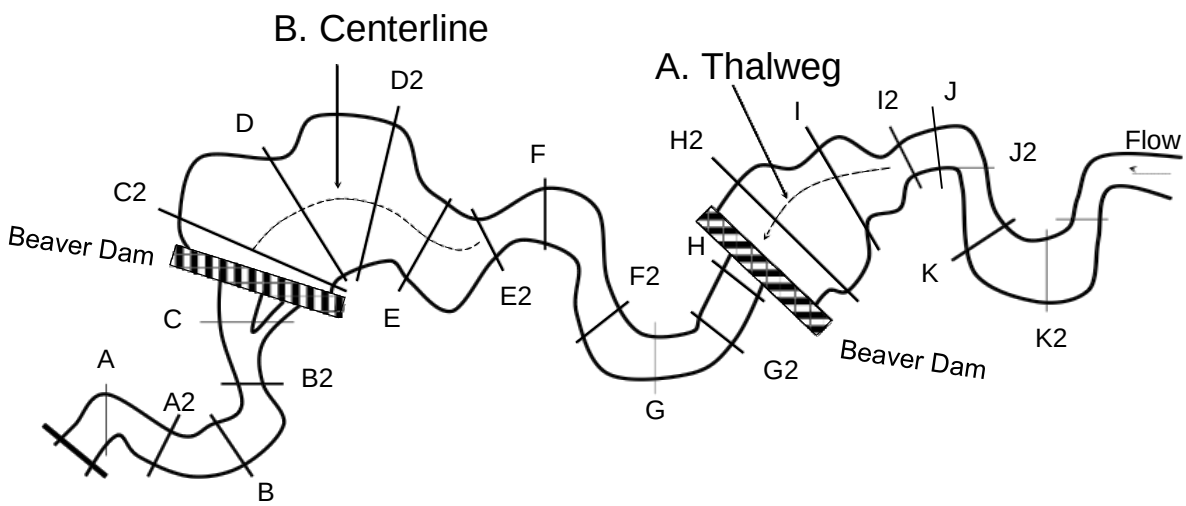


Figure 27— Depiction of a site with beaver dams. In beaver pool "A", transects are placed perpendicular to thalweg. In beaver pool "B", the thalweg cannot be located so transects are placed perpendicular to center line of the pool.

- Placing Transect Flags in Side Channels
    - It can be difficult to discern side channels beside and downstream of beaver dams;
    - Follow normal procedures for determining if measurements are taken in the side channel (see side channel section of protocol).
    - A side channel, even a flowing channel, must have a streambed that has <50% vegetative cover throughout its entire course. If at any point the channel has ≥ 50% vegetative cover, do not take measurements within it. For example if a beaver dam results in water flowing over terrestrial vegetation, do not record measurements there.

      Special Situation – this vegetation cover criteria is only used for side channels in beaver pond areas.

Record % of Site Impacted

- N = no beaver dams within the site and no evidence of beavers within the site 10m from stream channel on either bank.
- Y*= evidence of beaver within the site or within 10m from stream channel on either bank, but no beaver dams within the site.
- Low = approximately 0-40% of the site is impacted by beaver (i.e. dams, pools, and/or beaver glides).
- Medium = approximately 40-60% of the site is impacted by beaver (i.e. dams, pools, and/or beaver glides).
- High = approximately 60-100% of the site is impacted by beaver (i.e. dams, pools, and/or beaver glides).

UTM Coordinates

- Follow standard procedures.

Macroinvertebrates

- Collect macroinvertebrates downstream, but in close proximity to beaver dams. If your site does not fit into one of the following scenarios, do the best you can and take notes about where the macros were collected.
- Locate the most downstream beaver-impacted area within the site and take samples downstream from this location.
    - If there are 4 or more riffles in between the bottom of the site and the first beaver impacted area, collect 8 samples within the first four riffles downstream from the beaver impacted area.
    - If there are between 1 and 3 riffles between the most downstream beaver impacted area and the bottom of the site, evenly distribute your 8 samples within the available riffles.
    - If there are no riffles between the bottom of the site and the most downstream beaver impacted area, or the bottom of the site is impacted by beavers, select the following option which results in samples being collected closest to the beaver impacted area:
        - Collect 8 samples from the 1st four riffles downstream from bottom of the site.
        - OR, evenly distribute samples in riffles found within 50m downstream from the impacted area.

Cross-Sections, Pebble Counts and Large Wood

- Follow normal procedures in areas not impacted by beaver.
- Within beaver pools/impacted areas:
    - Use normal procedures when possible.
    - These measurements are based on bankfull width. If bankfull cannot be located or is underwater, then use water's edge to determine:
        - Boundaries for establishing cross sections, measuring bankfull widths, collecting pebbles and determining whether wood qualifies.

Pool Tail Fines

- Do not measure pool tail fines at beaver dam pools.

Photographs

- In addition to the standard reach photographs take the following additional photographs:
    - Top of beaver pool (DS) and top of beaver pool (US)
        - Take photographs of the top of the beaver pools looking both upstream and downstream.
        - Use the "criteria for determining the upstream boundary of beaver pools" to locate these positions (Table 8).
        - Hold the stadia rod on either bank at the upstream end of the beaver impacted area(s).
        - Take the photographs parallel to the channel at a distance that allows you to see as much of the beaver pool as possible.
    - Beaver dam (DS) and beaver dam (US)
        - Take photographs of the dam(s) looking both upstream and downstream.
        - Hold the stadia rod on/beside the dam.
        - Take the photographs parallel to the channel at a distance that allows you to see as much of the dam as possible.
    - Beaver pool overview
        - Take at least one overview photograph of each beaver pool/impacted area.
        - These photographs should be taken from a location where the greatest extent of the beaver pool(s) can be observed. This is often a hillside or terrace. Sometimes this is a difficult shot, try your best.

Pools

- Disregard standard pool criteria when evaluating a beaver pool.
- Beaver pool criteria (Table 11):
    - Beaver pools are areas where a beaver dam is slowing down and backing up water.
    - The dam does not have to be actively maintained.
    - The pool tail is the beaver dam.
    - Determine the <u>upstream boundary of beaver pools</u> using the following criteria (fig. 28):
        - Flowing water
        - "Normal" wetted width (i.e. not impacted by beaver)
        - Elevation above beaver dam height
        - "Normal" substrate (i.e. not all fines)
- Measuring beaver pools:
    - Full or partial: follow standard procedures
    - Length, Max and Head – follow standard procedures

Large Wood

- Follow normal procedures when possible.
- Determining whether or not large wood qualifies requires identifying bankfull. If bankfull cannot be located or is underwater in beaver impacted areas, use water's edge instead.

Transects

- Identify and record transects that fall in an areas impacted by beaver in the comment section.

Table 11—Characteristics for determining beaver pools and the area upstream of beaver pools.

Beaver Pools	Upstream of Beaver Pools
• Low/zero water velocity • Wide wetted width • Elevation below beaver dam height • Fine substrate • Level water surface is best indicator	• Flowing water • "Normal" wetted width • Elevation above beaver dam height • "Normal" substrate

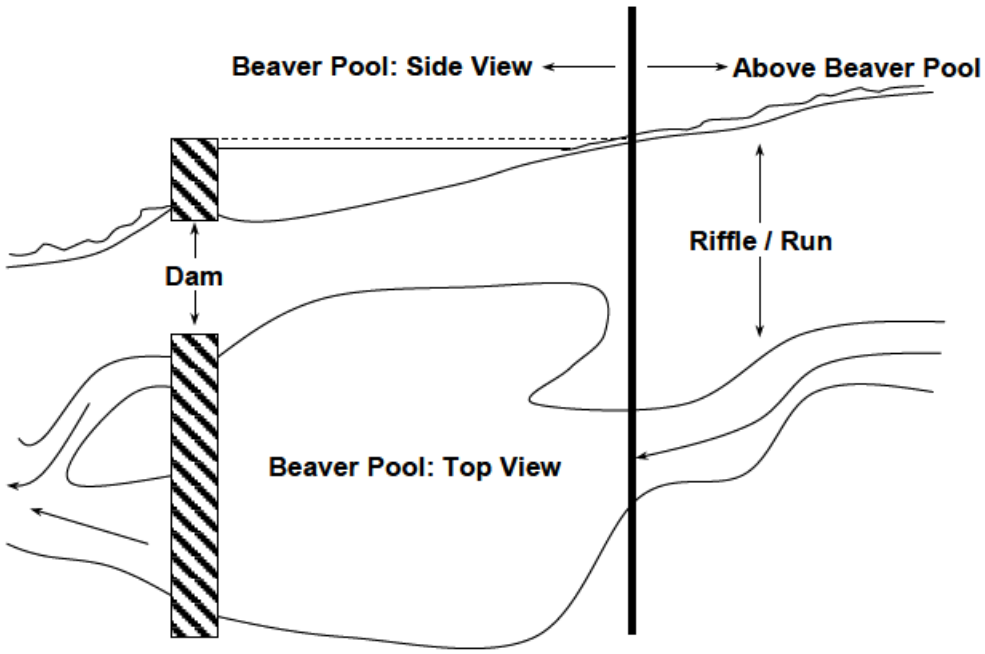


Figure 28—Top and side view of a beaver pool and how to determine the upstream boundary.

Appendix E – Procedure for Pressing Plants

Collect a specimen when a plant is identified as a potential invasive species and cannot be identified in the field. Only collect a plant specimen if the plant is abundant in number. If only one or two plants are present, leave the plant and take photographs. Store the plant press in a plastic bag to prevent the cardboard and newspaper from getting wet. In the vehicle, keep the plant press in a warm well-ventilated area to speed up the process of drying the specimens and to prevent growth of mold.

1. The plant press consists of alternating layers of corrugated cardboard and newspaper with plywood on each side. The cardboard layers allow for air circulation which helps the plant specimens dry more quickly. All the layers are held together and secured with straps.
2. When collecting a plant specimen, collect all parts of the plant including roots, stem, leaves, and flowers (if present). Clean the specimen of all debris and dirt.
3. Carefully place the collected plant specimen between two layers of newsprint. Be sure to spread the plant out so that all parts of the plant are visible. Make a note on the margin of the newspaper with the creek code, site number, date, and the suspected species name. Also make a note on the Terrestrial Invasives data form that a specimen was collected.
4. Place the newsprint layers in the plant press between two pieces of corrugated cardboard. Replace the plywood and secure the straps. Be sure to secure the straps tightly to create pressure which helps the plant specimen dry. The plant press should be kept in a warm area with good ventilation.

Appendix F – YSI Calibration

Calibration of the YSI will be conducted between stints or if unusual/erratic values are observed. Each morning the pH should be tested by placing the probe in the pH 4 and 10 solutions, if the readings are off plus or minus 0.1 for either solution the meter needs to be calibrated.

pH calibration

pH calibration will be conducted using 3 different pH standards (pH 4, pH 7, and pH 10). Calibration must always start with pH 7.

1. Fill the graduated cylinder with the pH 7 standard. Be sure the standard covers the black thermistor on the side of the gray probe bulkhead.

2. Press and hold CAL for three seconds

3. Highlight pH and press enter. If pH is not listed as an option, check the System Setup menu to ensure pH is enabled in the ISE Sensor Type menu.

4. Highlight 3 point and press enter.

5. If necessary, use the up and down arrow keys to adjust the pH buffer value. Note the pH mV reading which should be between -50 and +50 in buffer 7.

6. Press enter to continue to second point.

7. Rinse the sensor and place it in the second pH buffer (4 or 10). If necessary, use the up and down arrow keys to adjust the pH buffer value.

8. Wait approximately 30 to 60 seconds for the pH sensor to stabilize and for the temperature reading to stabilize. Note the pH mV reading. pH mVs in buffer 4 should be +159 to 180 mV from the previous buffer 7 pH mV value. pH mVs in buffer 10 should be -159 to 180 mV from the previous buffer 7 pH mV value.

9. Rinse the sensor and place it in the third pH buffer (4 or 10). If necessary, use the up and down arrow keys to adjust the pH buffer value.

10. Wait approximately 30 to 60 seconds for the pH sensor to stabilize and for the temperature reading to stabilize. Note the pH mV reading. pH mVs in buffer 4 should be +159 to 180 mV from the previous buffer 7 pH mV value. pH mVs in buffer 10 should be -159 to 180 mV from the previous buffer 7 pH mV value.

11. Press enter to complete the calibration or press Cal to cancel.

12. ‘Calibration Successful’ will display for a few seconds to indicate a successful calibration and then the instrument will return to the Run screen.

13. If the calibration is unsuccessful, an error message will display on the screen. Press the Cal key to exit the calibration error message and return to the Run screen.

Specific conductance calibration

For specific conductance submerge the probe in 1413 µS solution, if the reading is of plus or minus 14 µS (or 1% of solution if different from 1413 µS) it needs to be calibrated. Before doing so verify the specific conductance reference temperature is set to 25°C and the specific conductance temperature coefficient value is 1.91% (see manual on tablet).

1. Place at least 7 inches of the 1413 µS standard solution in the plastic container or a clean glass beaker.

Note: Do NOT use the 100 mL graduated cylinder. The diameter of the cylinder is too small for accurate conductivity measurements.

2. Turn the instrument on and allow the conductivity and temperature readings to stabilize. Press and hold the Cal key for 3 seconds. Highlight Conductivity and press enter. Next, highlight Sp. Conductance, and press enter.

3. Highlight uS/cm and press enter.

4. Use the up or down arrow key to adjust the value on the display to value of standard solution. Most conductivity solutions are labeled with a value at 25°C. If calibrating specific conductance, enter the value listed for 25°C (on bottle of solution). Press and holding either the up or down arrow key for 5 seconds will move the changing digit one place to the left. The Pro1030 will remember the entered calibration value and display it the next time a conductivity calibration is performed.

5. Press enter to complete the calibration or press Cal to cancel.

6. ‘Calibration Successful’ will display for a few seconds to indicate a successful calibration and then the instrument will return to the Run screen.

7. If the calibration is unsuccessful, an error message will display on the screen. Press the Cal key to exit the calibration error message and return to the Run screen. Specific Conductance Reference Temperature is the reference temperature used to calculate Specific Conductance. The reference temperature range is 15 and 25°C. The default value is 25°C. To change the reference temperature, highlight SPC Ref. Temp. and press enter to open the submenu. With the reference temperature highlighted, press enter to make the field adjustable. Next, use the up or down arrow key to increase

or decrease the value. Press enter to save the new reference temperature. Next, highlight the ESC-Exit box and press enter to close the submenu.

Specific Conductance Temperature Coefficient is the temperature coefficient used to calculate Specific Conductance. The coefficient range is 0.00 to 4.00. The default value is 1.91% which is based on KCl standards. To change the temperature coefficient, highlight SPC %/°C and press enter to open the submenu. With the temperature coefficient highlighted, press enter to make the field adjustable. Next, use the up or down arrow key to increase or decrease the value. Press enter to save the new coefficient. Next, highlight the ESC-Exit box and press enter to close the submenu.

Appendix G – Invasive Species Disinfection Protocol

Invasive Species Disinfection Protocol
Use protective, unlined rubber gloves and eye protection when handling the solutions and take extra precautions when handling undiluted chemicals. Have eye wash and clean water available on-site to treat accidental exposure. Both chemicals can cause irreversible eye damage and skin burns.

Field Gear

Survey gear to be disinfected:

- Chest waders
- Wading boots
- Neoprene booties
- Macro invertebrate collection vessel
- Macroinvertebrate net and handle
- Decanting sieve
- Fingernail brush (supplied for scrubbing mud from gear

Table 12—In the field disinfection equipment provided

Field Crews
• Bucket with Virkon® Aquatic • 5 gallon backpack sprayer with water • Stiff brush to remove mud from gear • Rubber gloves and eye protection • Virkon® test strips to check solution effectiveness

At warehouse

1. Scrub off any mud or dirt with a stiff bristle fingernail brush
    a. Mix a Sparquat and water solution by diluting Sparquat 256 with water using approximately 6oz (roughly ½ cup) of Sparquat to 1 gallon of water in a large Tupperware bin.
    b. Fully immerse boots (laces as well), waders, nets and net handles for at least 10 minutes.
        i. The solution can be used by multiple crews as long as it maintains its effectiveness (see testing solution effectiveness section below).
        ii. Once the solution is no longer effective dispose of the solution down a drain that runs to a water treatment plant.
    c. Rinse gear with water.
    d. Hang equipment in cages over the break and allow it to dry for the entire duration (6 days) between field stints.

In the field

1. At the site: Before leaving the stream all waders, boots, nets and net handles carried to the site that day, will be rinsed with stream water and any mud or dirt will be scrubbed off with a stiff bristle fingernail brush.
2. Be sure to decontaminate gear at least 100 meters from a water source.
    a. Use a ratio of 1/3 cup of Virkon® Aquatic to 1 gallon of water in bucket.
    b. Fully immerse gear for at least 20 minutes.
    c. After disinfection, thoroughly rinse gear with sprayer especially the foot/gravel guard portion of waders.
        i. The solution can be used multiple times as long as it maintains its effectiveness (see testing solution effectiveness section below).
        ii. Once the solution is no longer effective dispose of the solution away from any water sources preferably in a flat area where potential runoff to a water source is minimal.
    d. When possible, gear should be hung to dry overnight.

Testing Solution Effectiveness:
The solutions can be used for multiple disinfections as long they maintain their effectiveness. To test solution effectiveness:

Sparquat

1. Take 1/4 cup (2 oz.) of the Sparquat solution and mix with a gallon of water.
2. Test the diluted solution with “Quat Chek 1000” Test Paper.
3. Match up the color of the paper with the ppm’s on the color chart.
4. For optimal disinfection, the diluted solution should have a concentration of between 400 and 600 ppm.

Notes on Sparquat:
Sparquat 256 is a liquid disinfectant that contains didecyl dimethyl ammonium chloride, n-alkyl dimethyl benzyl ammonium chloride. These chemicals can be potentially dangerous if they come into contact with skin, eyes, or are swallowed.

Virkon® Aquatic

1. Take ½ cup of the Virkon® Aquatic solution and mix with a ½ cup of water.
2. Test the diluted solution with Virkon® Aquatic test strips by holding strip in solution for 1-2 seconds.
3. Remove and gently allow excess solution to run off. If the strip is black it is still usable if it is brown or any other color a new batch will need to be made.
4. Dispose of old solution away from water sources and preferably in a flat location.

Notes on Virkon® Aquatic:
Virkon® Aquatic is an oxygen based disinfectant containing simple inorganic salts and organic acids. The active substance in Virkon® Aquatic is Oxone®, or potassium peroxomonosulphate triple salt. This is an inorganic oxidant that degrades in the environment to potassium and sulphate ions. In total, about three quarters of the components of Virkon® Aquatic are inorganic and the primary decomposition mechanisms are abiotic, such as hydrolysis and catalytic decompositions, leading to simple inorganic salts at concentrations that are insignificant compared to those present naturally in the environment.

Firewood

When working in Humboldt, Mendocino, Lake, Sonoma, Napa, or Marin counties in California, as well as Curry County in Oregon, **do not** transport firewood or other plant materials outside of the 6th field watershed boundary. These counties have been quarantined by their respective states because of the presence of Sudden Oak Death Syndrome. Transporting firewood, soil, or plant materials can result in substantial fines and penalties. To be safe, it is best not to transport wood between any 6th field watersheds.

Appendix H – Field Database Management

GPS Waypoints (Laptop to GPS)

1. Launch BaseCamp. Select My Collection, click File then Import into “My Collection” (C:\AREMP\FieldData20XX\Outgoing\Waypoints)

2. Choose the watershed you need to load on the GPS. Select the file in My Collection, click Send to Device.

Downloading GPS (Garmin units) to Laptop

1. Launch BaseCamp then click Receive from device.

2. Below My Collection Folder and Data received from select the date and time stamped file and click File then Export.

3. Save as {year}{month}{day}{crew} e.g. 20100422Crew_4.gdb to C:\AREMP\FieldData20XX\Incoming\CrewX\StintX\CC\SiteX.

Backing up Data Forms on Site

Data will be backed up during the day to prevent accidental data loss should a tablet be lost or damaged to the point where data on the tablet is irretrievable. To back up the tablet the data will be beamed to the other tablet on site.

1. Prior to beaming the data on the tablet, go to Settings, Connections and below Connect and Share verify that NFC is on and under Data exchange verify that Android Beam is on and S Beam is off.

2. Take the cases off the tablets as beaming can’t occur through the cases. The tablet being beamed to doesn’t need to have excel open. From the excel spreadsheet to be beamed, near the top of the screen select the icon with the outline of a person with a plus sign in front of them.

3. When prompted with which format to use, select from the first drop down list (defaulted as workbook), Android Beam. Follow the on screen instructions to hold the tablets together back to back until beaming completes.

4. To check whether the beamed data made it to the other tablet, go to My Files, Device Storage and Download. If the beaming doesn’t complete or other errors are encountered first try restarting excel and if that doesn’t work restart the tablet(s).

Backing up the GPS file from tablet to laptop

1. Connect tablet to computer via USB cable. Open file explorer, on the tablet navigate to \Card\Android\data\gov.s1.s1mobile\Edit_Data\Waypoints.

2. Right-click on the file waypoints.json and choose Copy from the menu.

3. Paste the file into C:\AREMP\FieldData20XX\Incoming\CrewX\StintX\CC\SiteX. Rename file to include tablet identifier (i.e., ORABC1001_TA).

Downloading the Camera

1. Remove the SD card from the camera and place into reader on laptop (near the cover latch). Locate the photos on the camera card (using file explorer find the SD drive, usually E:\) and Copy/Paste them into the site folder.

2. C:\AREMP\FieldData20XX\Incoming\CrewX\StintX\CC\SiteX. Create a new folder for each camera used on a site (i.e., Camera_4A).

3. Review the photos to make sure required shots were captured at each site. Replace the card in the camera leaving ALL photo files on the card.

Copying Excel files from tablet to laptop

1. Connect USB cord from tablet to laptop, open file explorer on the laptop and navigate to, Computer\Aremp_C\Tablet\aremp\CC

2. Copy the excel files for the desired site and paste them into C:\AREMP\FieldData20XX\Incoming\CrewX\StintX\CC\SiteX

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